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ON BOARD OF A TORPEDO BOAT.

In a few days there will be begun at Toulon some experiments that have been ordered by Admiral Aube, in order to solve the question as to the transformation of the French navy, and to pronounce between the partisans of ironclads and those of torpedo boats.

While awaiting this memorable demonstration, it has seemed to you that it would be interesting to your readers to be initiated into the elements of the problem through a description of the torpedo boat, of the torpedo itself, and of the mode of maneuvering this new arm, which is one that is destined to revolutionize the art of naval war. This is why my collaborator, Mr. Benett, the photographer of your journal, and I, your humble servant, took a trip to Toulon, where all the torpedo boats from the ports of the ocean and English channel have been congregated for a month past.

FIG. 1.—EIGHTEEN MILES AN HOUR.

On the second day of our arrival, having learned that a start would take place on the following morning, we at daybreak passed through the, as yet, deserted streets of Toulon and the arsenal yards, and at the hour appointed found ourselves on board of the pontoon, where were moored the two boats that were to sail on that day. They were two torpedo boats of the first class, and of the same type as the one seen at Paris last year. They were 108 feet in length and 10¾ feet in width, and were provided with two tubes for launching torpedoes. It was at a launching of the Whitehead torpedo that we were to be present. We descended the narrow ladder suspended at the side of the pontoon; the ropes were cast off; the engine was set running, slowly at first and at full speed when we had got out of port; and then, while waiting for the exercises to begin, we made it our duty to inspect the interior of the little craft upon whose deck we had until then been standing. When I say *deck*, I use a somewhat improper expression, since, externally, the boat had throughout its entire length a surface as convex as a turtle's back

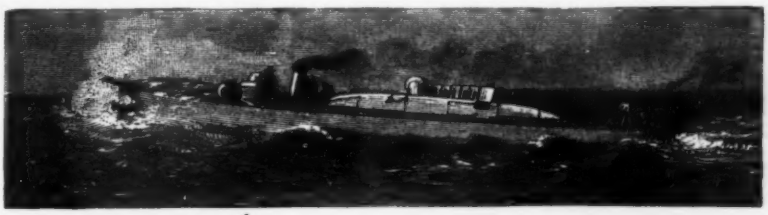


FIG. 2.

A narrow passage ran along the two sides of this sort of bulging roof, from which nothing projected but the smoke stack, the pilot house, and the funnel from which the blower sucks air and forces it into the furnace.

Internally, most of the available space was occupied by the motor. The engine, a compound one, had two cylinders, with independent pumps for the condenser, and made 380 revolutions per minute. The boiler was of the locomotive type. In order to make it produce the quantity of steam necessary for running at full speed, recourse was had to a forced draught. The entire furnace room formed a closed apartment in which a small blower, run by a special motor, compressed the air sucked in from the funnel above mentioned. This air, finding no other exit, passed under the grate and quickened the fire to an extraordinary degree.

The furnace room presents a curious spectacle when the boat is under full headway. Every instant, one of the stokers opens the door of the furnace and hastily throws in a shovelful of coal, and then quickly closes the door, since the influx of cold air upon the tubes would lower the pressure. Through the door thus abruptly opened, the furnace throws out a brilliant light upon the faces of the stokers, while the hum of the blower completes a striking impression of this hell in miniature. The place is very endurable, however, for, owing to the fresh air that is constantly forced into it, the furnace room of a torpedo boat is a much pleasanter place to stay in than those of most of the large steamers. Yet it has required special arrangements to prevent the dangers to which the men are exposed in these confined quarters. Let a water gauge break or a sudden leak occur, and the men would be burned alive, were it not that the automatic closing apparatus has rendered accidents of this kind impossible.

The captain's cabin and the engineers' room are back of the engine. The crew's quarters are forward. None of these is more than about three yards square, and it is very difficult to stand upright therein. This is the chief thing that renders torpedo boats uninhabitable during a prolonged trip. The crew of a first-class boat consists of two officers and seventeen men. Just imagine the existence of these nineteen persons huddled up in so confined a space, a prey to seasickness and deprived of rest, for the tremor renders sleep impossible, and the men are so shaken up by heavy seas that the most experienced sailors pay their tribute like novices.

Yet, from this point of view, the passages made by the torpedo boats to Toulon gave unhoped for results. Starting from ocean ports at the end of January or beginning of February, all reached Toulon in twenty days, without serious damage, although several of them were obliged to contend with very bad weather. The daring of our officers astonished foreign mariners, who saluted them with frantic hurrahs in the ports into which they put.

While we were receiving these explanations, the pitching of the boat had become very marked, and when we ascended to the deck we received a genuine shower from a wave that struck the bow and covered the vessel with spray. Fortunately, like the captain and crew, we had taken the precaution to put on a suit of tarpaulin, and, thus accoutered, we had the semblance of true tars, at which we were not the only ones or first ones to laugh; but it was not long ere we began to further and further appreciate the utility of our costume. The billows increased in measure as we advanced toward the open, and our boat, too swift and fine to rise on the waves like an ordinary craft, cleft the surges in front of her, while the two ridges left in the wake of her torpedo tubes in front threw up at every plunge a wheat-sheaf jet that the wind drove back over us.

Meanwhile, our photographer had pointed his objective toward the bow, and, owing to the apparatus being an instantaneous one, obtained the view shown in Fig. 1.

Finally, we reach the place where the experiments are to be performed; and now, while the crew is making the necessary preparations, let us make the acquaintance of the torpedo, as we already have made of the boat.

Whitehead's automatic torpedo, which is the one now almost universally adopted, is a steel spindle terminating in a double helix. It is a genuine submarine boat, 19 feet in length, divided into four compartments, whose arrangements are shown in Fig. 9. The explosive charge is in front, and consists of 66 pounds of dynamite. A hammer with several points assures of the firing of it, whatever be the angle at which the torpedo is approaching its goal. In the hind compartment there is a small three-cylinder motor for actuating the helix. This engine is run by compressed air stored up in the central compartment, and, as soon as the torpedo leaves its tube, is set in motion by a metallic finger that is hooked to the passage way, and that opens the cock communicating with the compressed air reservoir. Another apparatus of the same kind permits of determining in advance the time when the engine will stop, and, as the torpedo is then rising to the surface, it is possible by experimentation to thus regulate its run to distances of, say, 50, 100, or 200 yards, in such a way as to know where it will emerge after being fired. A third arrangement permits, on the contrary, of making

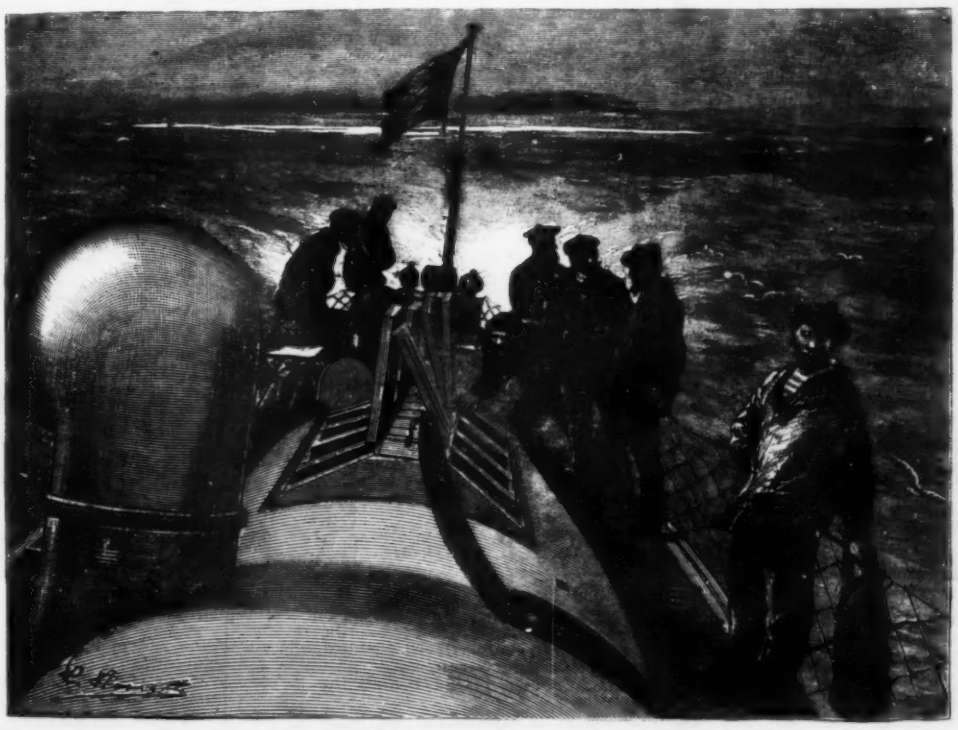


FIG. 3.—UNDER WAY.—VIEW FROM THE STERN.

it sink if it has made its trip without exploding, this being necessary in case of a battle, so that the enemy cannot fish up the lost torpedoes. It will be seen, then, that this torpedo possesses the following advantages: (1) It moves of itself in the direction whither it has been pointed, and at a speed of 24 miles per hour; (2) it explodes as soon as it comes into contact with an object, even in an oblique direction; (3) if it misses the object, and the apparatus has been regulated, it sinks, so as to escape the enemy; (4) if, on the contrary, the experiments be made without explosive charge, the torpedo will ascend to the surface after it has run to the distance for which it was regulated—such regulating being effected by bringing an index opposite the corresponding figure.

But all these remarkable features would be useless did not the torpedo satisfy one other condition, the most important of all—that of being able to remain at the proper depth to strike the enemy's ship in a vulnerable part. This indispensable property the torpedo possesses. The mechanism employed to effect this was for a long time a secret with its inventor, but is now well known, and we shall briefly describe it. It is placed in the second compartment forward, and consists essentially of a balance connected, through a rod, with a horizontal rudder placed behind the torpedo, back of the helices.

This granted, let us suppose that the torpedo is tending to rise to the surface in an inclined position, as shown in Fig. 10. The balance, P, will remain vertical because of its weight, but as it thrusts the rod toward the rear, the latter will cause a revolution of the rudder, G, which, on taking the position shown in the figure, will turn the torpedo's course in the direction shown by the arrow, that is to say, toward the bottom. If, on the contrary, the torpedo takes the position shown in Fig. 11, the balance, always vertical, will now act in such a way as to pull the rod forward, when the rudder will take the opposite direction and cause the torpedo to rise toward the surface.

Such is the principle of the regulating mechanism, the efficiency of which is secured by certain accessory arrangements, especially by a piston for checking too abrupt motions, and by a system of regulation that permits of determining the depth at which the torpedo

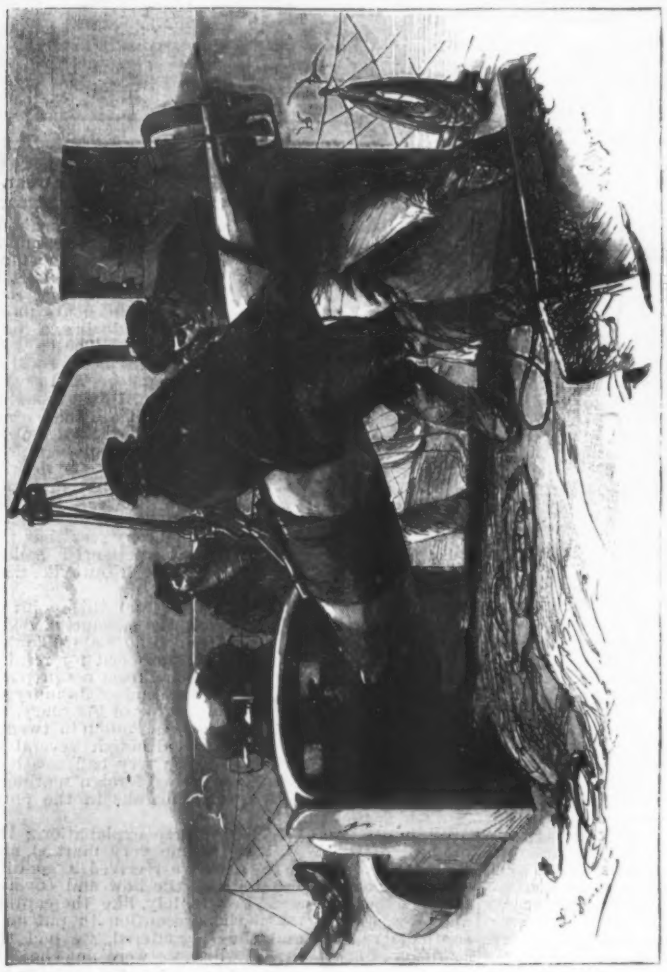


FIG. 5.—PUTTING THE TORPEDO INTO THE TUBE.

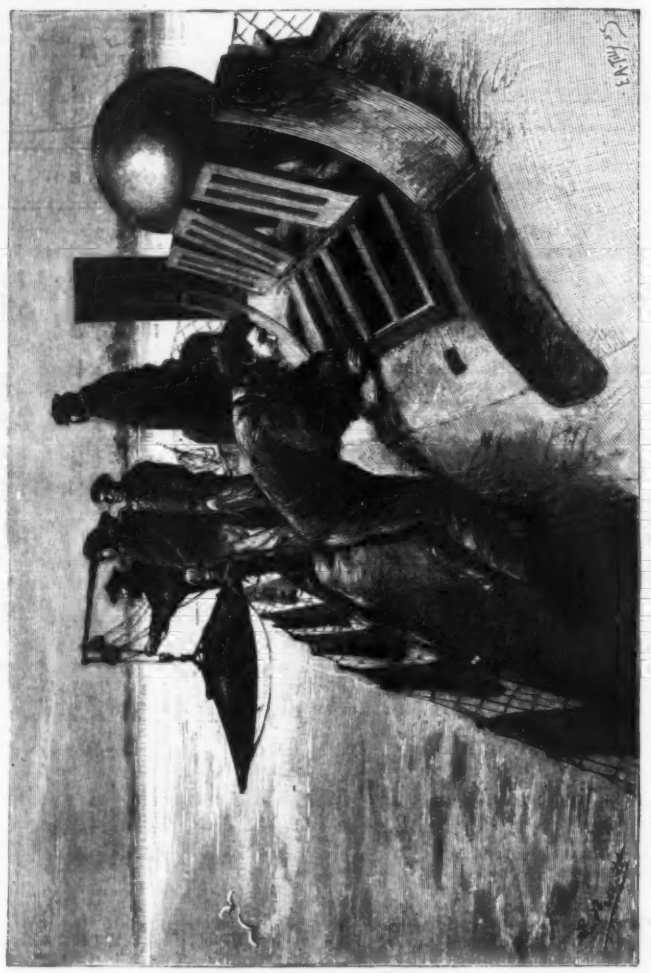


FIG. 8.—THE TORPEDO HOISTED ON DECK.

FIG. 4.—A BREAKER.

FIG. 7.—FISHING UP THE TORPEDO.

must remain. As we have stated, the Whitehead torpedo is 19 feet in length. Its weight is about six hundred and fifty pounds, and its floatability is 20 pounds, that is to say that at rest it floats upon the surface, and it requires the combined action of the helix and rudder to keep it under water. Each torpedo costs about two thousand dollars.

FIG. 6.—FIRE!

The two torpedoes that we took aboard when we started having been placed upon the deck, the men began the operation of putting them into the tubes (see Fig. 5). This is done as follows: The torpedo, supported by canvas, is suspended by chains from a crane at the side of the boat. Two men guide it to the end of the tube, which opens in front of the lookout's box, and

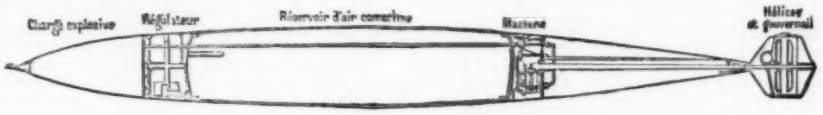


FIG. 9.—SECTION OF A WHITEHEAD TORPEDO.

then push it home. Formerly, the torpedo was thrown by compressed air, but at present a small charge of powder is used. Its exit from the tube is easily seen, so we station ourselves at the bow to witness the curious spectacle.

Fire! (Fig. 6) cries the captain. We hear a dull sound and, amid a small cloud of smoke, the torpedo flies through the air and plunges head foremost into the sea and sinks like a porpoise. The motions of its helix permit our eyes to follow its mysterious course at the surface, and then we lose sight of it. But it has already risen to the surface again and been seen by the sharp eyes of the sailors. It now forms a little black speck at a distance of 300 yards off—the exact distance for which it was regulated—and we now start to pick it up. It is this operation that is shown in Fig. 7. Two men enter a rowboat and make the torpedo fast to the chain, after which it is hoisted to the deck and placed in the tube again for another experiment (Fig. 8).

Sometimes the torpedo is lost sight of, or rather does not come to the surface again. In this case it is necessary to dredge in order to find it. But such an accident is rare, and occurred but once out of the numerous shots that we were witnesses of. On the contrary, we were struck by the precision with which the direction and length of the course were determined.

FIG. 10.

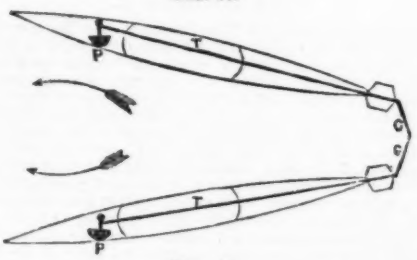


FIG. 11.

Will it be the same when, instead of making blank shots, we shall operate as in actual battle? Will the torpedo be able, under the emeny's fire, to approach to within a distance of two or three hundred yards, beyond which the firing loses all accuracy? Will not the torpedo be put out of its course by the swells made by the enemy's ship when the latter is under headway, or stopped by her protecting nets when she is at anchor? These questions and many others are to be answered by the experiments at Toulon.—*By a correspondent of L'Illustration.*

THE HYDRAULIC RAM.

THE PRINCIPLE OF THE HYDRAULIC RAM APPLIED TO LARGE MACHINERY FOR RAISING OR FORCING WATER, COMPRESSING OR EXHAUSTING AIR, OR MOTIVE POWER.

By H. D. PEARSALL, C.E.

I RECENTLY had the following case to deal with. Required, a large supply of water in a mountainous country 300 ft. above the level of the stream from which the supply was to be drawn.

The usual method would have been to take a canal off from the river some miles up. In this case it would have been necessary to go ten or fifteen miles up the river to get the required level. But the discharge of the river being much greater than the supply required, it was a question whether it would not pay better to use this water power to pump the supply required, rather than to make so long a canal to bring the supply by gravitation. If it was a question of pumping by turbines and force pumps, however, I found that the cost would equal that of the canal.

It then appeared to me possible that the pumping might be done on the principle of the hydraulic ram at very much less cost. But on application to the principal makers of rams, both in this country and in the United States, they could not supply me with any such machinery on the scale required, and on consideration it was evident that all known forms of rams were quite unsuited to the work. I therefore designed machinery similar to that I am about to describe (but larger than the machine here shown), and it will shortly be constructed at a very moderate cost. One machine has already been made, and gave very satisfactory results. I find the main features of the design are also applicable to a great variety of other circumstances, including air compression, raising sewage, etc., and accordingly the invention has been protected in all the principal countries.

The essential principle of the hydraulic ram is this: A mass of water is allowed to flow freely by the influence of gravity for a short time, and thus acquire a certain velocity, and therefore energy. Its free outlet is then closed, and the construction of the machine must be such that the acquired energy is expended against the resistance of an air vessel.

When it is required to utilize the power in forcing any kind of fluid, this principle obviously has advantage over any of the other three principles on which water-power engines are constructed, inasmuch as it may be made to accomplish the desired object at one operation and in one machine, instead of through a more or less complicated cycle of operations and machines. Even where it is required to use the power for other purposes, this principle still has advantages in some cases.

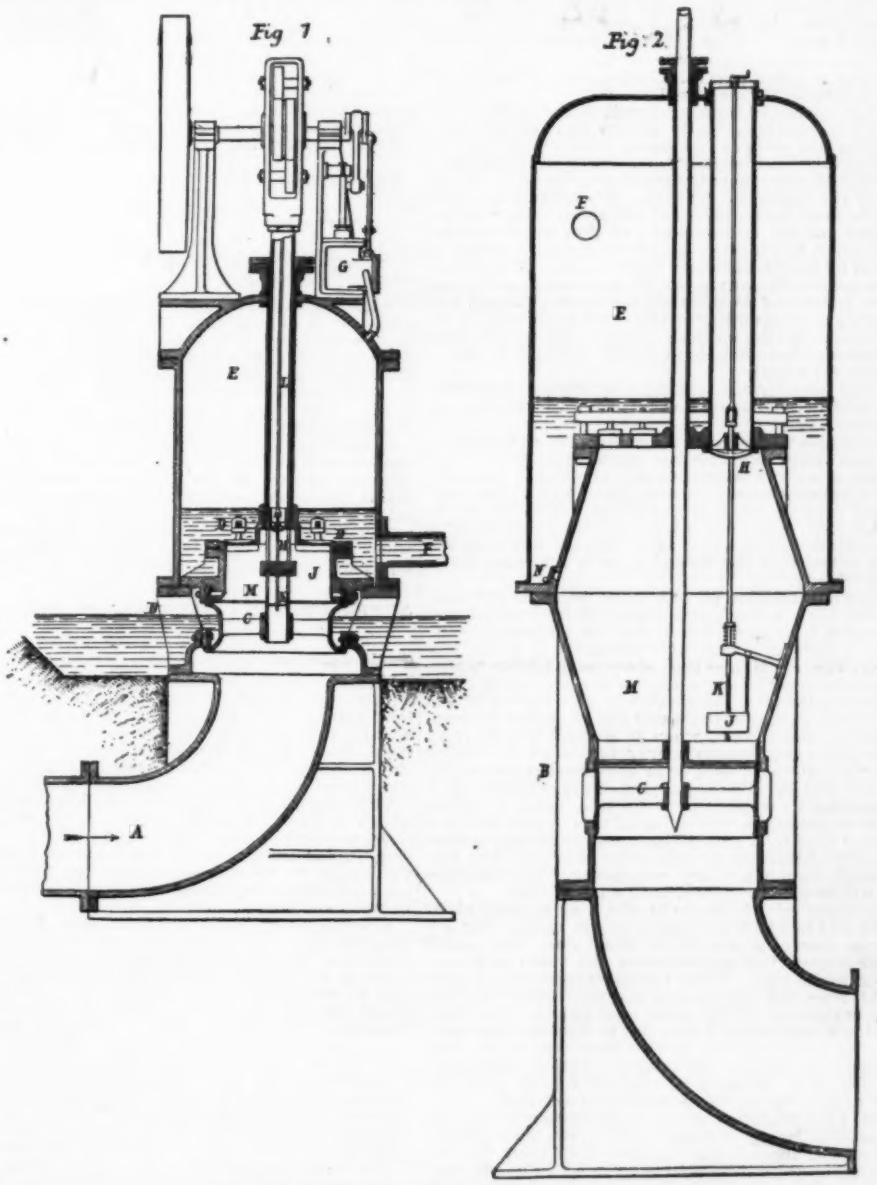
Hitherto, however, almost the only application of the principle has been in the common ram invented by Montgolfier just a hundred years ago, and very little improved on since. Almost all the attempts at improvement have been only slight modifications, and have retained features which have unfitted these machines for use on any but a small scale, as more or less violent shocks are inevitable accompaniments of their action. Indeed, this violent action has come to be regarded by many people as essential to the working of such machines, and it is commonly supposed that there must necessarily be something of the nature of a blow. Hence the name of "ram."

Careful consideration, however, accompanied by experiment, demonstrates that this is an error. Violent shock is not essential to the action of machines on this principle, though it is an invariable accompaniment of all existing machines. But it can be avoided, and by its avoidance the efficiency is not only not impaired, but it is increased. The name of "ram" is therefore a misleading one.

I may add that, even if rams of ordinary construction could be used on a large scale, they would not be economical, as the greatest velocity of water admissible is low, and therefore the number of such machines required would be large.

The greatest advance toward the true method of construction of such machines on a large scale was made by the celebrated engineer Sommeiller, in the machinery he made for the Mont Cenis Tunnel. His design was a great departure from all other types of rams, and avoided their chief defects. It proved the possibility of using the principle on the largest scale, and his designs had sufficient success to cause the erection of twenty large machines, ten of which were erected after the others had been in operation for more than a year.* His design, however, was as expensive as a combination of turbines and pumps would have been, and it is therefore easily understood why the very fair success which he attained has not led to the general use of his machinery. By the method of construction

*The machines here referred to were illustrated on page 281 of the twelfth volume of *Engineering*.



PEARSALL'S HYDRAULIC RAMS.

I have devised, one machine of the same size as one of Sommeiler's will, under the same circumstances, do as much as ten of his machines did. This statement is startling, but it will be clearly seen by the explanation below that this is the fact. The defects which were discovered in the practical working of his machines have also been efficiently provided against.

One form of the machine is shown in Fig. 1 on the preceding page. A somewhat simpler construction is possible for machines of this size and smaller, but I shall not refer to these further here, as I wish to describe only the application to large machinery. As regards rams of the ordinary size, say 4 in. and 6 in. pipes, I do not refer to them at all; the ordinary construction leaves nothing to be desired in simplicity, and is good enough for such small machinery.

In Fig. 1, A is the flow-pipe conducting water from the source to the tail-race, B. C is the main valve, opening and closing communication with the tail-race. D D are delivery valves, opening into the air vessel, E. F is the delivery pipe. The main valve is opened and shut by means of a small motor, G, which is worked by the compressed air in the air vessel. H is an air valve carrying a float, J, the distance of which from H is adjustable by means of a screw, K, and wrench, L.

The action is as follows: The flow-pipe being full of water, the main valve is opened by the motor, and water floats into the tail-race, thus putting into motion all the water in the flow-pipe, the chamber, M, also emptying itself into the tail-race and being filled with air through the valve, H. After the flow has continued for a certain time—say, for example, two seconds—the main valve is closed by the motor. During the closing of the valve the flow of the water is not checked, as it can rise without resistance in the chamber, M, the air freely escaping by the valve, H. The motion of the valve, C, need not therefore be rapid.

When the main valve is closed, and the water has reached a certain height in the chamber, it raises the float, J, and closes the air valve, H. If the float be adjusted so as to close the air valve while there is still some air in the chamber, this air is then compressed (by the energy of the column of water) till its pressure equals that in the air vessel, when it and some of the water is forced into the air vessel. Water thus continues to flow into the air vessel until the energy of the column of water in motion is exhausted by the resistance of the air vessel, when the column of water comes to rest and the delivery valves gently close. The action of the motor is timed so that after this has taken place the main valve is again opened and the cycle of operations is repeated. Of course, water flows out of the air vessel continuously under pressure through the delivery pipe, F.

It is not necessary ordinarily to confine and compress more than a very small quantity of air in the chamber. If the small quantity necessary to supply the motor be confined, it will also be ample to provide all the cushioning that is desirable. In starting the machine, however, it is an advantage to adjust the float so as to force in a considerable quantity of air, so as to fill the air vessel with compressed air, and reduce the water level to a height of a few inches only above the valves, at which height it can easily be kept, thus avoiding any mass of water above the valves, and utilizing the full capacity of the air vessel.

In the method of working described above, the water in the flow-pipe is evidently always in motion in one direction (the state of rest being momentary), and its velocity varies periodically from zero to a certain predetermined maximum; the mean velocity is therefore half of the maximum velocity. It is evident that the size of a machine requisite for any given power is dependent on the mean velocity of flow which can be maintained, but it is the maximum velocity which is limited by considerations of friction, etc. The reason of the great difference in size between one of these machines and one of Sommeiler's, for the same power, will therefore now be understood; as the mean velocity of the water in Sommeiler's machine was only one-twentieth of the maximum velocity, whereas in these machines it is half.

A very considerable velocity, very greatly exceeding that used in common rams, is found to occasion no difficulty.

I have also worked such a machine in a somewhat different way; opening the main valve before the column of water has come to rest, or when it has only been somewhat retarded; and I find the action sufficiently smooth when worked thus. This of course further reduces the size of the machine required for a given discharge of water, as it further increases the mean velocity in the flow-pipe with the same maximum velocity.

Fig. 2 is a machine on the same principle for compressing air. As the parts are similarly lettered and the action is identical, it will not be necessary to describe it in detail. The chief difference is in the size of the chamber, M, and that of course the delivery pipe takes off above the water line in the air vessel. The nicety of adjustment attainable in the closing of the air valve is such that the water can be made to come to rest at the instant when it reaches the delivery valve plate, and thus no energy is wasted in forcing water into the air vessel, or in compressing air which is not forced in. The upper part of the chamber, M, is surrounded by water, and there is a valve, N, which serves to produce a circulation of this water, which is thereby kept cold, and the compression is consequently nearly isothermal, and therefore effected at less cost of energy than in any dry compressor. This machine will utilize 40 horse-power, with a fall of 30 ft.

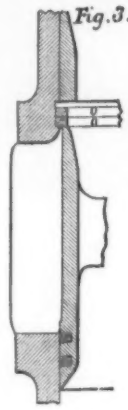
The main valve is shown in Fig. 1 as a double-beat valve, and in Fig. 2 as a hollow piston valve. Fig. 3 is a larger view of a portion of this valve. The upper packing ring, O, is separate from the valve, and is retained in the pipe. When the valve is moved up close to this ring, any pressure in the pipe forces the ring against the edge of the valve (and against the pipe), making a water-tight joint; but in opening the valve the ring has not to be carried past the orifice, thus avoiding the wear of an ordinary piston valve; and yet there is no bringing of the valve hard on to its seat, as in ordinary valves with fixed seatings.

Fig. 4 is a diagram taken from the experimental machine by a Crosby indicator, and shows how smooth and regular the action is, and how little there is of the violence ordinarily credited to a "ram." The efficiency of the machine when this diagram was taken was very good.

I have also designed several other forms of the machine for the following cases: 1. Where it is desired to pump other water than the power water without mixing the two. 2. For exceptionally high or low falls. 3. For raising water by suction. 4. For exhausting air. 5. For discharging the "waste" water under pressure, as, for instance, using water from a main with a pressure of 100 ft., 20 ft. of the pressure may be used in such a machine, and the waste water still have a pressure of 80 ft.

The uses of such machines as this will be obvious from the above descriptions. They are available wherever any considerable water power is to be utilized either for raising or forcing liquids, or for compressing or exhausting air. They also afford a good means of obtaining motive power for any other purposes where the power is required at a distance from the source of power, the power being transmitted either by water under pressure or by compressed air. The

Fig. 3.



arrangement also constitutes an inexpensive means of utilizing water power which is not constant in its action, such as tidal power. From the small cost of very large pumping machinery on this plan, a large quantity of tidal water may be passed through such a machine at extreme high and low tides, raising part of such water to a reservoir on any convenient elevation in the neighborhood, whence a constant water power may be drawn.

The most obvious advantage of machines on the principle of the hydraulic ram is that it is the only practicable method of doing in one machine the work which otherwise requires a combination of turbines or water wheels and pumps or air compressors, and of performing in one operation the work otherwise requiring a cycle of operations. The results of this simplification are a marked economy both in first cost and in working expenses and increased efficiency.

As regards the features of the actual design, the following points may be noted: The motion of the water is not interfered with by any tortuous passages, and is subject to no reversal or regurgitation or impact against mass. The valve has no heavy mass falling on solid surfaces, but its motion is at moderate speed, and is one of gradual acceleration and retardation, and the construction is such as to permit of adequate strength when made of any size, however large. The water may be used at a considerable velocity, and the work done by a machine is therefore very great for its size. This will be seen by the example in Fig. 2. The construction is simple, and there is but little to keep in order. The form is such as to give the greatest strength with the minimum of material.

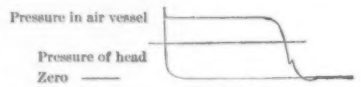


FIG. 4.

A machine was constructed last year and experimented with in London, with the result of giving an efficiency of over 80 per cent., and proving that the action was smooth and free from violence, that a high velocity of water gave no difficulty, and that the action of the machine corresponded very exactly with what had been determined theoretically, and was under easy control.—*Engineering.*

ARTESIAN WELL SINKING IN THE SIERRA NEVADA.

To the Editor of the Scientific American:

Throughout the year now closing with the closing winter, I have been so interested as an observer of local artesian well sinking, and its rather phenomenal results, that I am led to believe that a few briefly stated facts connected therewith will interest readers of the SCIENTIFIC AMERICAN, especially those not familiar with the mountainous regions of the West.

The location of the work referred to is Sierra Valley, which is some twenty-five miles in length, with an average width of about eight miles, and lying (or sitting, just as one chooses to look at it) in northeastern California, in the Sierra Nevada, just 5,000 ft. above sea level, about fifty miles north of, and some 2,000 ft. below, Lake Tahoe.

Everything in sight about this valley indicates that at a time not very remote it was the bed of a body of fresh or nearly fresh water, which, as the bed gradually filled, flowed out through Beckwith Pass, a depression in the valley's northwestern wall, leaving only a small, sluggish stream that varies in volume with the changes of the seasons, and is known as one of the numerous heads of Feather River. Nature, while doing so much for man, always leaves something for him to do for himself. She lifted this valley up and up till the main bulk of its watery filling slid from its face, but did not so distribute what she saw fit to leave as to supply the wants of even a majority of its present population, hence attempts to obtain artesian water.

The first artesian well machinery, working by what is known as the "hydraulic jetting process," was introduced here about a year ago, having been purchased by a joint company of ranchers. The undertaking was of course somewhat hazardous, and numerous and widely varying opinions were ventured upon as to the character of the material to be penetrated, and the quality of the water, should any be brought to the surface. But work once commenced, demonstration of the problem was soon reached. A three-inch well less than three hundred feet in depth, and sunk at an average rate of fifty feet a day, discharged sixty gallons a minute. Fears that this result might be diminished, perhaps entirely lost, in going deeper, determined the proprietor to hold fast to "the bird in the hand;" but in wells which followed—and they followed in quick succession—deeper and deeper went the drill, proving in almost every instance that in Sierra Valley well sinking is somewhat like thinking—the deeper we go, the more we get. As the result of a year's experimenting, commenced in doubt with one small machine, we can now point to five machines at work, and to some seventy-five flowing wells, the deepest more than a thousand feet, and the strongest discharging about three hundred gallons a minute. As a rule, the water is quite pure, with a temperature but a little above that of surface water; the exceptions are a few, having an odor and a taste as if the water came from, or in rising passed through, deposits of vegetable matter; a few that are warm, and two or three almost boiling hot.

One of the last exceptions is now utilized by its enterprising proprietor in supplying heat for an incubator, from which, it is said, runs a stream of chickens limited as to size only by the number of eggs given it to act upon. As to the character of the material penetrated, well sinking here seems to prove that the water filling of a depression at least more than a thousand feet in depth has been "raised out" by the present more substantial filling, undoubtedly eroded and carried down from its walls by the teeth and hands of time, that through the ages know no rest. But time, whose work is always finished and always renewed, having up to this date had time to but slightly solidify, tamp down, this filling, with the exception of an occasional thin stratum a little more compact than the main body, the drill almost drops through it, going down in some instances nearly a hundred feet an hour, about as fast as the workmen can attach the necessary rods.

From the fact that some of the water is tinctured with sulphur, the filling has been attributed to direct volcanic action; but being out of the line of recently active volcanoes, the theory that the sulphur is due to the igneous character of the rocks of its walls seems more tenable. These rocks are mainly granitic, porphyritic, and feldspathic, lime and quartz being noticeably absent, knowing which it is easy to form tolerably correct opinions as to the character of the material below, which is occasionally stratified by interposed layers of sand, so thin, however, as to occasion but little trouble, and composed largely of finely ground magnetic iron.

It cannot be expected that the apparatus employed here will bring to the surface any but the lightest fossils. My collection from this source consists of a few plant stems and pieces of leaves, half a dozen tiny shells, still beautifully hued, a couple of minute fishbones, and a few small scales.

Now, an absorbing question with us is, Will these wells, which are cased down only a few feet, continue to flow; or, owing to the plastic, restless character of the material penetrated, will the walls by and by be so forced together as to restore our highly prized fountains to their subterranean pathways?

Loyalton, Cal., May, 1886.

[Continued from SUPPLEMENT, No. 543, page 8670.]

ARTESIAN WELLS.

REQUISITE AND QUALIFYING CONDITIONS OF ARTESIAN WELLS.*

By THOMAS C. CHAMBERLIN.

HEIGHT OF FLOW.

1. *Measurement.*—When the flow has been confined to the tube by either of the above devices, it is an easy matter to determine the available height to which it may be carried. Where the pressure is moderate, this is easiest determined by adding pipe above the surface until the water no longer rises through it. But when the pressure is great, it would ascend to an inconvenient height, and a pressure gauge of any available form may be substituted, and the height to which the water would rise, if suitably tubed, computed; each pound of pressure per square inch equaling 2·31 feet of rise.

2. *Prognostic Estimate.*—The testing of the full strength of a generous fountain, already secured, is a comforting task, quite in contrast to the solicitude one suffers in attempting to estimate beforehand what height may be anticipated. Theoretically, the water will rise at the well to the same height as the fountain head, and will flow at any elevation less than that. But the leakage of the confining strata and of the well reduce the height to which the water will rise, while the friction suffered in the long passage through the rock and the well will further lessen the altitude at which flow, of any notable vigor, will take place. Deduction must be made for all these elements. The special conditions which affect the estimate have been previously considered.

All the light that can be drawn from a careful scrutiny of these is demanded. The prudent expert will, however, seek assiduously a better and more truly scientific basis for his judgment. In almost every district wells have been attempted, and their results—whether successful or otherwise—if critically analyzed and interpreted, give valuable data, even though somewhat removed from the locality under consideration. The importance of recording and preserving the precise results of all enterprises, whether good or ill, cannot be too strongly urged upon drillers, geologists, and citizens alike, nor is it, perhaps, out of place here to urge that an intelligent respect be paid to

* From the Fifth Annual Report of the U. S. Geological Survey, J. W. Powell, Director.

† These conditions are so varied that I donbt the propriety of attempting any general statement of the deduction to be made from theoretical height. For Southern Wisconsin, I have found an allowance of about 1 foot for every mile between the collecting area and the site of the well to be as near a general estimate as I feel prepared to make; but even this is subject to considerable modification in special situations, and could not safely be adopted for other regions.

the facts so developed; the respect, however, is no more important than the intelligence.

DETECTION OF FLOW.

It has been remarked above that the water may rise from the bottom to some higher portion of the well, and there find escape by passing off laterally through the upper strata. In the absence of control, the water does not always rise and overflow. It is a matter of some practical moment, therefore, to know when a stream is struck which may yield a flow at the surface when put under proper control. (1.) Such a stream usually discovers itself by a rise of water in the well, but this is not always the case. (2.) Some influence on the action of the drill is liable to be felt, which may arouse suspicion. (3.) In any instance of a strong flow, the drillings are apt to be carried away, so that when the sand-pump fails to bring these up, or brings only coarser material, there is good reason to believe that a stream has been struck, and the proper tests should be made. In enterprises that do not require a voluminous flow, tests should usually be made when such indications appear. It is ordinarily desirable to test the capacity of any stratum which gives any of these or other indications, before sinking to a lower one. It is advisable to make provision in the contract for such tests, since it is not always to the interest of the driller, once his machinery is set up and well at work, to stop at the more limited depth. The capabilities of the flow may be tested by the use of a tube and seed bag, or by rubber packing, as explained above.

Negative and False Tests.—1. It is possible, in perfect honesty, to make both a negative and a false test. Suppose that two porous beds, A and B (Fig. 28), separated

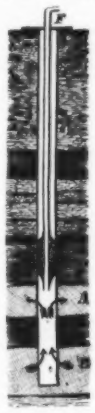


FIG. 28.—Section of a well, illustrating a negative test.

by an impervious layer, are traversed, and the testing of the first has been neglected, either because it failed to give encouraging indications or for other reasons. It is now desired to test these. Suppose the seed bag or rubber packing be placed above the upper one.

Now, if both bear a water-level equally high, the test will be fairly made, and the result will indicate their combined capacity; or, if both heads are at least as high as the surface at the well, the test may be accepted. But suppose that the bed, A, has been cut into by erosion, or been reached by crevices, or is otherwise defective, while the other, B, remains intact and bears an elevated fountain-head. Under these conditions the water may flow from B, through the bore into A, and escape laterally through it, as illustrated in the figure. Now, in this case the result may be either simply negative or positively false and misleading. If the lateral leakage through the stratum, A, effectually disposed of the flow from B, and there was no leakage in the upper portion of the well, the water in the test tube would stand during the test at essentially the same height as before, and the result would be negative, merely failing to indicate a possibility that really existed. If, on the other hand, there was lateral leakage through the upper strata as well as through A, neither alone being quite competent to dispose of the flow from B, then the introduction of the test pipe would cut off the upper leakage, leaving the bed, A, unable to dispose of the entire flow. In this case there

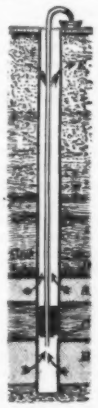


FIG. 29.—Section of a well showing a partial and misleading test.

would be a rise of water in the tube, and, possibly, a flow. The mischievousness of a test of this sort lies in the fact that it appears to be a true test, because it shows some result, while in reality it is false and misleading. The true test in this case can only be made by placing the packing between the porous beds, A and B.

2. Take another instance where two porous beds, as A and B, Fig. 29, have been traversed. Let the packing be placed between these. Then (1), if A equals B in productive capacity, water will stand at the same height within and without the test-pipe *if there is no leakage in the upper beds.* (2) If the failure to flow was due to such leakage, then a flow will result from B, but the additional flow which might be secured from A is lost (see figure). (3) If A has a greater head than B, and if there is no loss above, the water in the test-pipe will actually be lower than that outside, as illustrated in Fig. 30. This may be said to be an *inverted test*, and is

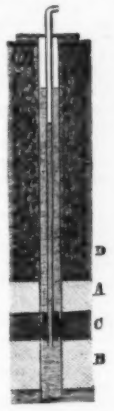


FIG. 30.—Section of a well illustrating an inverted test.

less misleading than the false and negative tests, since it plainly indicates an error of manipulation. I have known such a case of reduced head as the result of an attempted test. (4) If, however, there is in this case considerable lateral waste in the upper strata, the valuable flow from A will be lost, just as before the test was made, while B may give a rise in the tube, or even a flow, which would foster the impression that a fair test had been made, while in reality the greater flow has been lost. (5) If A gives a feebler flow than B, but has an equal head, the test will fail of being completely satisfactory only in excluding the feebler flow from A. (6) If, however, A has a lower head, and is a possible means of escape for the flowage from B, then the packing has been placed at the right point, and the test gives the best results.

3. In still another case let A and B represent porous beds (Fig. 31), the lower of which is so conditioned as to drain the upper one by virtue of a lower outcrop, in the manner previously explained and illustrated in Figs. 13 and 14. (1) First, if the drainage loss below is not complete, and if the packing is placed above A, as shown in Fig. 31, I, the result will be negative, if there is no leakage in the upper strata. (2) Should there be considerable loss there, it will be cut off by the tube and packing, and some rise in the tube will be the result in most cases. In either instance the result is misleading, particularly in the last, because the small rise of the water is apt to allay any suspicion as to the effectiveness of the test. The real fact, however, remains that the flow from the productive stratum is mainly lost below. (3) Suppose that the packing is located between A and B, as in Fig. 31, II, it will then

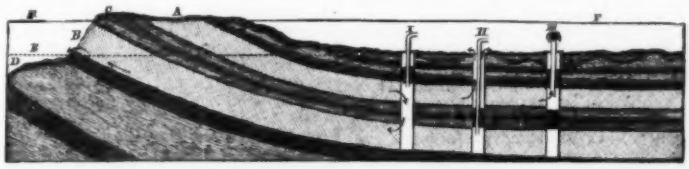


FIG. 31.—Section of strata and three wells, showing one correct and two erroneous tests. These wells are assumed to be independent of each other, and are placed together on the diagram merely for convenience.

shut off the flow from A, while that in B, because of a lower outlet, will fail to flow. Now, if there is opportunity for lateral leakage in the upper strata, the water from A will rise in the well *outside* of the test-pipe and pass off into these open upper beds. (4) But if no such opportunity is afforded, it may rise to the surface and overflow *outside* of the test-pipe, while the water within the test-pipe will probably be found to be lower than before the test was made. The proper method of testing wells known or suspected to present these conditions is to sink a simple bag of seed or other obstruction to a point in the impervious stratum between A and B, which, when it tightens in its place, will shut off the flow below. Then a tube, with packing sunk to a point above A, will effectually cut off all leakage in the upper strata, and the full capacity of the water bed, A, will be tested.

These examples, while not exhaustive of possible cases, illustrate the nature of defective tests and the deceptive conclusions liable to be drawn from them. The remedy is manifest. Test each water bearing stratum as it is encountered, or else vary the final tests so as effectually to exclude all liabilities to error.

EFFECT OF TIME ON FLOW.

It is a common observation that the discharge of artesian wells declines in time, and the impression has somewhat obtained that this general fact is a necessary one. It is not unimportant, therefore, to consider the causes that lead to decline, since this is likely to be the best approach to the vital question, whether it is inevitable or preventable.

1. *Decline from Loss of Gaseous Aid.*—We have thus far neglected a class of wells which flow, not from the pressure of an elevated fountain head, but from the expansive force of pent-up gases, which are either disseminated throughout the water itself, like the carbonic acid in the soda fountain, or are contained in some hidden reservoir in communication with the water which is thus forced out. Wells of this class ejecting petroleum, gas, and water are familiar features of the oil regions.

A well whose flow arises from any such cause must decline as the gas relieves itself by escape, unless it is continually renewed by generation below, which is doubtless very rare. But while this class of wells lies without the province to which we are limiting ourselves here, it illustrates strikingly a cause of flow which has some little exemplification in the wells under consideration. Most waters that have stood pent up in the depths of the earth contain, absorbed within themselves, a greater or less amount of carbonic acid and other gases. When relief reaches these by the penetration of the well, they expand and aid in lifting the column, both by their elasticity and levity, so that when first struck the water frequently flows with a sparkling vigor not permanently retained. Gradually the pent-up gas relieves itself and the flow correspondingly declines. The main effect of this, however, is doubtless brief, and so far as this element is concerned, the flow settles down into an essentially stable current.

2. *Decline from Loss of Heat.*—An exceedingly slow and almost infinitesimal decline may be assumed to result from a change of temperature. The water entering at the fountain head has about the average temperature of the region. That issuing from deep artesian wells is warmer by several degrees. This relative warmth by lightening the column aids, in some little measure, the flow. The heat is derived from the deeper strata which the artesian current traverses, and manifestly they are continually losing what the stream is continually gaining, and a slow process of cooling the strata is going on. The temperature of the current must decline accordingly, and the aid derived from the warmth be correspondingly lost. This decline is probably much too slight and too slow to be of practical moment, though I am not aware what observation may teach on this subject, if, indeed, it has received attention.

3. *Decline from Increase of Leakage.*—Reference has previously been made to the disposition of the water as it rises in the well to find lateral escape through the upper strata. It is, of course, the intention of the well-sinker, in putting in his final delivery tube and packing, to cut this off by lowering the pipe to a point below which this does not take place. But, being expensive, it is not inserted deeper than thought strictly necessary. Now, many beds permit lateral leakage in a feeble degree, which are yet in the larger sense impervious, as, for example, many of our limestones. The lateral leakage which they permit may be at first imperceptible, but under the high pressure, minute streams thread their way through the tiny openings in the rock, and, little by little, by virtue of their wearing and solvent action, increase their channels until at length, through their united influence, they make themselves felt upon the greater stream. In many cases there are some hundreds of feet of limestone exposed to this action beneath the packing.

Again, since the packing occupies, at most, but two or three feet in the bore, the water, pressing from below, may thread its way around it through the capillary passages, and, at length, by enlarging these to more considerable dimensions, find partial relief in that way.

It is evident that both of these sources of leakage may be corrected by inserting the tube and packing to a lower point.

4. *Decline from Closure of the Bore.*—It is a well-known fact that some rock-beds, under great pressure from the strata above, "creep" toward artificial openings, such as the shafts and drifts of mines. So small a perforation as a well-bore, with its walls arched against an inward yielding, and filled with a column of water exerting from one-third to one-half as much pressure as the rock, does not invite this action. But some beds are soft and plastic, as the clays and clay-shales, while others are loose and mobile, as the sands and half coherent sandstones. Beds of these kinds, at considerable depths, where the pressure is severe, may yield, and tend to close the bore. Of course, the friction of the current is increased by the assumed stricture, and tends to cut it away, but perfectly pure water has little corrosive power. In the more stable formations it may be doubted whether this is often an occasion of decline. In the newer and less consolidated beds it is to be apprehended that it is. Closure of this kind could be tested by lowering an expanding gauge through the delivery tube; and it could, probably, in most cases, be successfully reamed out with an expanding drill without removing the tubing.

Closure may also arise from an accumulation of sand and other fine matter brought into the bore by the inrushing current.

5. *Decline from Defective Piping.*—Obviously, growing defects in the tubing and packing would favor decline. Iron piping rusts rapidly, especially if there are corrosive ingredients in the water. If the decline sets in only after a few years, and rapidly increases, suspicion points in this direction.

6. *Decline from Exhaustion.*—The too current notion that a subterranean pool which has been struck by a well supplies it for a time and then becomes exhausted, may be dismissed without much consideration, for no such pool will be apt, under existing hydrostatic laws, to leave its deep-seated repose and pour itself out upon the surface, merely because an opening is provided. If forced by a distant head, that head may be drawn down, but the pool will remain as full as ever. I can conceive of nothing but the collapse of the inclosing walls that could force it to evacuate, and that would give a violence of ejection and suddenness of cessation corresponding to the rate of collapse, a phenomenon quite different from that commonly referred to the exhaustion of a subterranean pool. The exhaustion is not in the imagined pool under the well,

but in the distant elevated edge of the water-bed. If there is but a limited accumulation there, and it is not promptly renewed from the surface, the well may gradually draw it off. In doing this, it is obvious that the head is, little by little, lowered, and hence has less and less forcing power. The flow, therefore, declines gradually. A decreasing flow from this cause will fluctuate with the rainfall upon the distant collecting area, and will renew itself with returning wet seasons. A decline followed by a permanent refusal to flow points to some other cause. Decrease of flow due to overdraft on the supply, or exhaustion of the fountain head, has a more adverse promise than those previously noted, since it is, in the main, irremediable.

7. *Detection of the Cause of Decline.*—From a consideration of the preceding causes of decline I venture the suggestion, without knowing from experience how far it may be practicable, that the precise way in which the decrease takes place may give a clew to the cause. The decline from exhaustion of stored gases should set in early and proceed rapidly for a time, and then more and more slowly as the exhaustion of the gas proceeds. That from heat may be neglected. That from enlargement of capillary pores would set in tardily and increase slowly, and at length probably produce a total stoppage. That from rusting of pipes or decay of packing would not be felt at all at first, and would probably increase rapidly when once started, until an entire cessation ensued. That from closure of the bore would be slow in coming into action, if due to the "creeps" or filling, but if due to caving, it would be sudden and probably complete. That from exhaustion of the fountain head would be gradual and decreasing, and its flow would be renewed with every fresh atmospheric supply.

CHARACTER OF THE WATER.

1. *Temperature.*—It is a well-known fact that the temperature of the earth increases as its interior is penetrated at an average rate of one degree for every 50 or 60 feet, and that waters arising from the deeper strata partake of their elevated temperature. The water of the celebrated well at Grenelle, near Paris, has a temperature of 82°; that of St. Louis, 73·4°; that of Louisville, 76·5°; that of Charleston, 87°. When the temperature is notably above 70°, it may be rendered serviceable as a source of heat. The hospital of Grenelle is said to be heated by the famous well of that place. Below the temperature suitable for this purpose the warmth renders the water less immediately palatable, but facilitates its distribution through pipes in cold weather by preventing freezing.

2. *Chemical Impregnations.*—The water which descends from the clouds is nearly free from mineral ingredients. As it penetrates the earth, it gradually becomes mineralized by dissolving the soluble constituents of the strata. The extent to which it thus impregnates itself is, among other things, dependent on (1) the character of the soil and rock through which it percolates, (2) the depth which it penetrates, and (3) the time it remains confined within the earth. It is not strange, therefore, that waters rising from great depths should frequently be mineralized in a notable degree. The saline combinations may be various, but the constituents are but the soluble ingredients of the strata. When these constituents are such as to impart to the water undoubted hygienic and remedial properties, there may be no occasion to regard this impregnation as unfortunate.

But when considered with reference to common domestic purposes, the mineralization of artesian water is a condition of debatable value. For drinking purposes, a moderate mineralization is, on the whole, probably beneficial, rather than injurious, though authorities are not entirely agreed upon this point. For laundry uses, the property of hardness, usually communicated by lime and other salts, is objectionable, and the incrustations deposited upon boilers detract from its serviceableness to manufacturers. It is usually, though not universally, harder than the river and lake water of the region. In all cases where city supplies are contemplated, opposing preferences are apt to arise, when the choice lies between artesian water on the one hand and lake or river water on the other. Those to whom purity is a supreme consideration, whether it be freedom from infectious germs, deleterious organic solutions, or mechanically suspended sediment, lean strongly to an artesian supply. With those who, neglectful of these considerations, are more influenced by industrial utility, a surface supply usually commands preference.

To the general rule, that artesian waters are more impregnated with mineral salts than surface waters, exceptions are found in those cases in which the rainfall directly penetrates sandy soil, and thence passes on at once into an open stratum of quartzose sandstone, from which, without penetrating deeply, or remaining long within the earth, or coming in contact with calcareous beds, it is brought again to the surface. Such waters are often notably soft and relatively free from mineral impregnations.

There seems to be sufficient evidence to justify the statement—in itself very rational—that the water of an inclined stratum increases in mineralization with its depth and distance from the outcropping edge. At the upper margin, it is only rain-water, filtered through the soil, which has already been subjected to much leaching, which is, indeed, often little more than the insoluble residue of disintegrated rock. As it penetrates farther, it increases the earth-material with which it has come in contact, and is commingled with waters that have slowly percolated through the capillary pores of the adjacent strata, which, being relatively impervious, are as yet but partially leached of their oceanic salts, much less their rock substance. Manifestly, the farther it penetrates, and the longer it remains embedded in the deep strata, the more mineral matter it has opportunity to dissolve from them.

Now, on the first opening of an artesian well, the waters rising from the depths are possibly such as have long remained within the strata from want of any other means of exit than the slow methods of diffusion and capillary penetration. But, on the opening of a generous outlet, these pour forth upon the surface, and those that flow down from the fountain head to take their places pass less slowly through the stratum, and, presumably, are less impregnated with mineral ingredients. In the lapse of time the track of the current must become relatively more leached of its soluble constituents than portions impregnated with more nearly stagnant water. Hence the progressive tendency of artesian water is toward less mineralization. Whether the amount of this reduction is of practical consequence has not, so far as I am aware, been satisfactorily determined by careful observation, but the impression that the water becomes gradually purer from extraneous matter is a not uncommon one.

LIMITS IN DEPTH.

The vitality of a false notion is often surprising. It is sometimes crushing to our faith in the survival of the fittest. A striking illustration is found in the widespread popular delusion that an abundant flow may always be found "if you only go deep enough." When we consider that rain-fall is the great source of the waters of the land, and that the strata, as a rule, become more compact as depth increases, it is apparent that a very nearly opposite presumption should displace this fallacy. It doubtless arises from the fact that the immediate surface beds are more or less dry, and that it is necessary to penetrate some small distance to reach the subterranean water-bed. It is not realized that when this is once fairly reached, the most richly supplied aqueous horizon is found. The beds below grow closer in general, and present less opportunity for accumulation. If, in imagination, the relatively dry surface were removed, the rest of the earth might be conceived as most copiously filled with water in the more open upper portion, and less and less permeated below, because less and less open to receive water. This is, of course, only a general law, subject to much modification, according to the kinds of rock which overlie each other in succession.

In view of this general presumption, it is folly to sink deep wells without some definite knowledge that a rock of porous nature lies below and presents the requisite conditions for supplying a fountain. The occasional luck of ignorance may find a flow, but it is not soothing to our pride of popular intelligence to note how thickly our land is punctured by needless follies, largely encouraged by the above fallacious conception.

Preliminary to sinking a well, as complete knowledge of the underlying strata as it is possible to obtain from the usual methods of geological inquiry should be gathered, and the depth of the well limited to that necessary to reach the most productive stratum. To be sure, there are regions in which, in the absence of specific knowledge, or when such as can be obtained is indecisive, the sinking of a deep well to test the strata is warranted by the importance of a favorable result; but the uncertainties of the issue and the financial hazard of the undertaking should be frankly faced. It is not to be inferred from these conservative remarks that failures do not result from the opposite cause, that wells do not often come short of success by stopping short of the proper horizon. The existence of such failures only adds to the importance of specific knowledge in lieu of broad proverbs and loose maxims.

The succession of strata is so various in different regions that general rules are few. There is one, however, of wide application whose observance would save the useless expenditure of large sums. The Archæan rocks, as before observed, are exceedingly unpromising of success in themselves, and do not overlie productive beds. Whenever, therefore, in the progress of drilling these are struck, work should cease, unless there are specific local facts warranting a deviation from the rule. A provision to this effect should be inserted in all contracts, since it is in the interest of both parties, for the drilling is usually very difficult and unremunerative at any ordinary rate per foot, while, there being no rational prospect of good results to the owner, the amount he pays, however unremunerative to the driller, is a dead loss to himself. It is not sufficient to insert the term *granite* instead of *Archæan rock*, as is sometimes done, since quartzites and other crystalline rocks not fairly embraced under the term granite, even in its more extended sense, are included in the Archæan series, the penetration of which would prove alike unprofitable to driller and owner.

Locally, there are other formations at which drilling should cease, either because no productive beds occur below, or because they are known to lie at unavailable depths. Specific knowledge of such local conditions is requisite for guidance in these instances.

THE ART OF SINKING WELLS.

It does not fall within the proposed scope of this article to enter upon a detailed discussion of the art of sinking wells, of the difficulties encountered, and of the ingenious devices by which they are overcome, but a few general statements may not be without interest in themselves, while they lead the way to other topics whose discussion is more imperative.

1. *Superiority of Methods in the Oil Regions.*—Were it within our province to discuss the art of drilling, it would be necessary to go beyond the field of artesian wells proper to find its highest development; for whatever may have been the result in other respects of the traditional strife between water and oil, that never agree, the latter has proved itself the master as an incentive to the development of ingenuity and skill in the art of drilling. The innumerable practical difficulties that rendered the earlier attempts tedious and hazardous at the best, failures often, have been largely mastered, and the sinking of wells one or two thousand feet deep is now a daily successful occurrence. To the oil regions, therefore, we must turn for the finest examples of technical skill in this art. For an exposition of this development, detailed with much particularity, and accurately illustrated, I can refer to nothing better than the report of John F. Carll on the oil regions of Pennsylvania.*

The methods of sinking artesian wells in common use are either slight variations from those current in oil regions, or represent some of the earlier methods in leading up to the present stage, and which remain serviceable for the less exacting demands of the shallower wells. All are modifications of the ancient chisel drill, which, by being lifted and let fall, cuts its way into the rock, being at the same time rotated to keep the hole round, uniform, and vertical.

2. *Use of the Diamond Drill.*—To a limited extent, the diamond drill has been employed. It is essentially an iron tube, armed at its lower extremity with cutting diamonds so placed that when rotated the tube cuts its way into the rock, leaving a cylindrical core in the center. A current of water, forced down the interior of the tube, and rising outside, carries away the drillings. It is in great favor with geologists and explorers, because the core gives a complete, unmutilated section of the rocks penetrated.

3. *Driven Wells.*—In sinking wells in drift, or other unconsolidated beds, simpler and cheaper devices are much in use. The most expeditious, when practicable, is the "drive well;" merely a tube, armed with a conical point, and a section of perforated pipe, forced into the ground by a maul, or by dropping a block or beam upon it, pile-driver fashion, until the perforated section reaches the porous stratum, when the water flows in and rises to the surface. This, of course, is limited to shallow wells, whose confining stratum offers no serious impediment to penetration. The bowlders of drift-beds sometimes impose obstacles, but in so simple an operation it is easy to withdraw the tube and try again.

4. *Earth Augers.*—In other instances earth augers are used, not unlike the common post auger, by means of which a bore of large size is rapidly and cheaply sunk. This is, of course, subject to like interference in stony clays or very coarse gravel.

5. *Cost of Wells.*—The expense of sinking a well manifestly varies greatly with the character of the strata, the depth, and the cost of power and labor in the region in which it is sunk. So far as my knowledge extends, it is not customary to vary the rate for the different kinds of sedimentary rocks, limestones, sandstones, and shales. Where required to penetrate granite or other crystalline rocks, an increased rate is very properly demanded. To attempt to distinguish between limestone, sandstone, and shales would lead to endless difficulty, as they not only graduate into each other, but are often intimately interleaved. The driller, familiar with the general character of the strata of the region, demands an average price, dependent on depth. While this varies, an approximate idea of the expense may be obtained by reckoning from $2 to $3 per foot for the first 1,000 feet, and an increase of a half dollar per foot for each 500 feet below that down to the limits practicable for drilling. To this is to be added the cost of tubing, which will vary greatly with the situation and character of the strata.

RECORD OF DRILLINGS.

The importance of keeping a careful record of the strata encountered in the progress of drilling needs emphasis, both on account of its practical and scientific value. The record should embrace not only accurate measurements of the successive strata traversed, accompanied by careful notes on their character and a full suite of samples, but also a record of all features relating to their water-bearing nature. Some of these, that seem trivial, often have much significance when critically examined and expertly interpreted. If the diamond drill is used, the cores, of course, furnish an exceptionally excellent record in themselves, if completely and carefully preserved and placed in their natural succession, besides being an interesting exhibit of much geological interest. Since, however, these are apt to be disarranged, they should be consecutively numbered, as taken out, and, since the softer portions of the core are liable to be much broken, supplementary measurements and notes are also desirable.

From what has been previously said, the importance of knowing precisely where to locate the permanent packing is apparent. Economy dictates that it be placed as near the surface as prudent, not only to save the cost of pipe, but also the reduction in the size of the bore caused by the insertion of the pipe, and the consequent increase of friction. At the same time, it is important to cut off all dangerous lateral leakage, and forestall an early decline in the flow of the well. An accurate knowledge of the strata penetrated is the only trustworthy means of doing this.

Again, when any defect in the first tubing and packing develops itself, a careful record is a valuable aid in detecting the nature and cause of the defect, and determining the means for its correction. The original driller may have thought his general observation and memory a sufficient guide for the first adjustment, but if years have passed, neither the driller nor his memory may be within available reach. The party contracting for the sinking of a well should invariably insist upon an accurate written record, which should be preserved and transmitted with the property. The authorities of civic corporations superintending public wells should place such records on file among official documents.

When resort is had to the use of torpedoes, the precise point at which they are to be located is a matter of vital importance, and the exact depth at which the effects of explosion will presumably produce the greatest effect can only be determined by an accurate knowledge of the succession of the strata and their varying characters.

Recurring to the discussion of the testing and control of waters derived from different beds, the need of specific knowledge becomes self-evident.

It is unnecessary to enlarge upon the scientific value of such records, not only as guides in the antecedent study of proposed wells, but as direct and positive knowledge concerning the geological column and many subsidiary phenomena.

In summation, the aid rendered in determining temporary tests, the location of permanent packing, the detection of the cause and place of defects leading to decline, the relocation of any necessary repacking, the firing of explosives, either at first or subsequently, the predetermination of success or failure in other attempts, and the light thrown on various geologic questions, combine to emphasize the importance of careful records of the drilling and the preservation of its products.

Interpretation of the Drillings.—To the inexperienced the interpretation of the drillings offers some puzzles and pitfalls, though the phenomena are in reality quite simple. When the prudent driller has procured the insertion of a clause in the contract releasing him from his obligation when "granite," or the Archæan rocks, have been reached, a question for the arbitration of the geologist is apt to arise, since the other contracting party, failing of success thus far, not unnaturally desires to drive deeper. Now, the question would not usually be difficult or misleading were the drillings which are submitted merely those of the rock at the bottom of the well. But the rods or ropes

* Second Geol. Surv. Penn., Oil Regions, iii.

and tools of the drill, by their vibration, strike the walls of the well and rattle down grains or fragments from the strata above, and these, mingling with the true drillings, often produce a curious intermixture, and if the simple fact of such a double origin is neglected, a wild interpretation will be the inevitable result. The harder the bottom rock, and the more friable the rock above, the greater the disproportion between the true and the false drillings, especially when rods are used instead of rope. When working in granite, beneath Potsdam sandstone, I have sometimes found less than 10 per cent. of the samples brought up by the sand-pump to be bottom drillings. In these cases rods instead of ropes were used. The basis for discrimination between the true and the false drillings is found in the angular forms and the fresh fractures interpreted in the light of previous knowledge of the strata, the rate of the drilling, the character of the stroke, and other attendant evidences. Only the direct stroke of the drill is usually competent to give chips of hard rock of any notable size having the fracture forms peculiar to such an origin, and these are to be sought as the best indications of the constitution of the rock being wrought upon.

In the penetration of hard rock, steel flakes and splinters broken from the drill, and metallic films rubbed from it, are not uncommon features. Brought up wet, they soon rust and are liable to be interpreted as ferruginous ingredients of the rock The inconsistency of their color with the magnetic susceptibility which the unoxidized core retains betrays their true character.

AREAS OF FAVORABLE, DOUBTFUL, AND ADVERSE PROBABILITIES.

It is the proper function of geological investigation to ascertain the stratigraphic conditions which determine success or failure. As the outcome of completed investigations, it is possible to map off the face of the country into (1) areas in which success may reasonably be anticipated, (2) areas in which the conditions are nearly balanced, and in which local and indeterminate conditions will decide success or failure, and (3) areas in which the conditions are adverse, if not altogether prohibitory. The service which such maps are competent to render in encouraging the utilization of an important resource, or in teaching caution and circumspection where uncertain results alone can be anticipated, or in forbidding useless expenditure, need not be argued. Such classification of areas has been attempted in one or more States,* but a general map for our vast domain is yet a hope of the future.

From the foregoing considerations it is manifest that the areas of probable success must be the relatively low tracts, that the areas of adverse probabilities are the relatively high regions, and that the doubtful belts lie between. The fallacy of an abundant supply, "if you only go deep enough," is altogether overshadowed by the singular notion, not altogether uncommon, that high lands are favorable locations for artesian fountains. The origin of this surprising illusion I am unable to fathom.

The greatest sources of indefensible expenditure are (1) the selection of a location of too great relative altitude, in defiance of the simple fundamental principle of artesian flowage, and (2) the penetration of unproductive strata, after all favorable chances have been exhausted, in disregard of the fundamental laws that govern the distribution of subterranean waters.

Special Study.—In the face of so many possibilities of failure, the importance of a special consideration of the assemblage of conditions that surround a proposed undertaking, in a region not previously proved, or in a situation in any important respect dissimilar from those already tested, need not be pressed. The central purpose of this paper has been to call into prominence the varied qualifying conditions that solicit consideration, and, if possible, stimulate and aid those special discriminative studies which lead to an intelligent confidence of success or a prudent withholding from failure.

* Geol. Wis., vol i., p. 697.

ON THE EXPLOSION OF HOMOGENEOUS GASEOUS MIXTURES.

AT a recent meeting of the Institution of Civil Engineers, the paper read was on "The Explosion of Homogeneous Gaseous Mixtures," by Mr. Dugald Clerk, F.C.S.

Experiments were made by Hirn in 1861 to determine the pressures produced by the explosion of mixtures of inflammable gases with atmospheric air. The pressures of the explosions were much lower than calculation gave, assuming that the maximum pressure of the explosion was coincident with the complete combustion of the gas. For a mixture of 1 volume of hydrogen and 9 volumes of air, calculation gave 5·8 atmospheres, whereas experiment only showed 3·25 atmospheres. Coal gas behaved in a similar way. Bunsen's experiments, made in 1866, corroborated Hirn's results, and went a step further by proving that the heat was not all evolved, even when the vessel was completely filled with flame; that was, the deficiency of pressure was not due to the burning out of the flame at one part before ignition occurred in the other part of the vessel. More recently, a series of papers had appeared describing numerous experiments by Messrs. Mallard and Le Chatelier, in all of which experiments a large deficiency of pressure was observed. Messrs. Berthelot and Vieille also supported their conclusions. The author had made the experiments described in this paper, partly to obtain much needed data for gas engine work, and partly to study more fully the nature of the actions occurring during explosion. His experiments corroborated those of previous workers, in proving indisputably the existence of the limit to increase in pressure; the deficiency in pressure being very great, seldom more than one-half the heat of the explosion being evolved at the moment of maximum pressure. The explosion vessel used by the author was a strong cast iron cylinder, the internal space being 7 in. in diameter and 8¼ in. long. Upon the upper cover was mounted a Richards indicator, from which the ordinary reciprocating drum had been removed and a revolving one substituted, driven by a falling weight and suitable gear; a fan moving at a high velocity served as governor. The revolving drum was enameled, and a soft black-lead pencil, held by the indicator motion, marked upon it a line caused by the movement of the indicator piston. A pair of insulated points projected through a plug in the bottom cover, and served to ignite the mixture when a spark from a coil and battery was passed between them. The line traced on the drum by the indicator showed the amount of rise in pressure, and the times of rise and fall in terms of revolution of the drum. The tracing was precisely analogous to the indicated diagram from an engine. The rising line was due to the explosion, the falling line was due to the cooling action of the cold walls upon the hot gases. The tracing was in fact a record of the rapidity, intensity, and duration of an explosion. Careful tracings were made, which were reproduced. Tables were given of the results obtained from various mixtures of air with Glasgow coal gas, Oldham coal gas, and pure hydrogen.

GLASGOW COAL GAS AND AIR MIXTURES.

Temperature of Gas before ignition, 18 deg. Cent.; pressure, atmospheric, 14·7 lb.

Experiment.	Proportion of gas by volume.	Mean Pressure.	Max. temp. Centigrade.	Time of explosion.
			Deg.	Sec.
a	1	52 lb. per square inch above atmosphere...	1047	0·28
b	1-12	63 " " "	1365	0·18
c	1-10	69 " " "	1584	0·13
d	1-8	89 " " "	1780	0·07
e	1-6	96 " " "	1918	0·05

OLDHAM COAL GAS AND AIR MIXTURES.

Average Temperature of Gases before ignition taken as 17 deg. Cent.; pressure, atmospheric, 14·7 lb.

Experiment.	Proportion of gas by volume.	Maximum Pressure.	Max. temp. Centigrade.	Time of explosion.
			Deg.	Sec.
a	1-15	40·0 lb. per square inch above atmosphere	806	0·45
b	1-14	51·5 " " "	1033	0·31
c	1-13	60·0 " " "	1202	0·24
d	1-12	61·0 " " "	1220	0·17
e	1-10	78·0 " " "	1557	0·08
f	1-8	87·0 " " "	1753	0·06
g	1-8	90·0 " " "	1792	0·04
h	1-6	96·0 " " "	1812	0·055
i	1-5	80·0 " " "	1565	0·16

HYDROGEN AND AIR MIXTURES.

Temperature of Gases before ignition, 16 deg. Cent.; pressure, atmospheric, 14·7 lb.

Experiment.	Proportion of hydrogen by volume.	Maximum Pressure.	Max. temp. Centigrade.	Time of explosion.
			Deg.	Sec.
a	1-7	41 lb. per square inch above atmosphere.	826 to 909	0·15
b	1-5	68 " " "	1358 " 1559	0·026
c	2-7	80 " " "	1615 " 1929	0·01

From these experiments the relative value of the different mixtures of gases for producing power might be calculated. In Glasgow gas, the most economical mixture for non-compressive engines was 1 volume of gas to 11 volumes of air; Oldham gas, 1 volume of gas to 12 volumes of air. Comparing Glasgow gas and Oldham gas, the pressure of explosion of the former was longer sustained than that of the latter, and the pressures produced for a given volume were equally good; therefore, more power was obtained from a cubic foot in Glasgow than in Oldham. Pure hydrogen, which was very commonly thought to be the best, was shown to be the poorest. An engine which would indicate 10 horse power with coal gas would not indicate more than 3·7 horse power with pure hydrogen. The author's results were in complete accord with those of previous experimenters on the question of the existence of a limit; in no case did the heat accounted for by the explosion pressure amount to more than 77 per cent. of the total heat present as inflammable gas; in the majority of cases it was little over 50 per cent. In the author's opinion, no single theory previously stated accounted for all the phenomena of these explosion curves. Although all experimenters were agreed upon the fact of the deficiency of pressure, they differed upon the causes producing this result. Three theories had been propounded:

Theory of Limit by Cooling.—This was Hirn's theory. It supposed that when explosion occurred, a point was attained when the cooling effect of the inclosing walls was so great that heat was abstracted more rapidly than it was evolved, and accordingly the combustion, although continuing, did not proceed with sufficient rapidity to prevent fall of pressure.

Theory of Limit by Dissociation.—This was Bunsen's theory, and was undoubtedly very largely true. The fact that no unlimited temperature could be attained by combustion was so conclusively established, both by science and by practice, that gradual combustion from that cause might be safely taken as occurring at the higher temperature of gas engine explosions. There was, however, a difficulty in applying it to all cases. In an experiment with Oldham coal gas, when the maximum temperature of the explosion was 806 deg. C., the apparent loss of heat was 65 per cent., while in an explosion with a maximum temperature of 1,733 deg. C. the apparent loss of heat was only 38 per cent. With hydrogen mixtures the same thing occurred: Maximum temperature 900 deg. C., apparent evolution of heat 55 per cent.; maximum temperature 1,700 deg. C., apparent evolution of heat 54 per cent. If dissociation entirely explained the limit, then, as water and carbonic acid must be dissociated more at the higher than at the lower temperature, the deficiency should be greater at 1,700 deg. C. than at 900 deg. It was not so. Some other cause than dissociation must, therefore, be acting to check the increase so powerfully at the lower temperature. The problem was more complex than had been hitherto supposed.

Theory of Limit by the Increasing Specific Heat of the Heated Gases.—According to Messrs. Mallard and Le Chatelier, the specific heat of nitrogen, oxygen, and the compounds formed by combustion increased greatly at the higher temperatures; dissociation acted only to a trifling extent below 1,800 deg. C. The heat of combustion was all evolved at the maximum temperature of the explosion; but as the specific heat changed, calculation from the specific heat at ordinary temperatures was erroneous. The deficiency of pressure was therefore a measure of the increased capacity of heat of the reacting gases. The crucial point of this theory was the supposition that combustion was complete at the maximum temperatures; if it could be shown that combustion was not complete, then the whole theory fell to the ground. The author's experiments seemed to him to prove conclusively that combustion was incomplete; this has been done by a study of the curves of the rates of cooling of various explosions.

Fuller Account of the Phenomena during Explosion.—In the author's opinion, no single cause explained the limit in all cases of explosion. The actions operating were much more complex than had been generally supposed. To him it seemed that much confusion had arisen through neglecting to distinguish properly between two distinct and separate phenomena which occurred during explosion. These phenomena were the inflammation or filling of the explosion vessel with flame and the completion of the burning which was so originated. The explosion curves with coal gas showed some extraordinary features; in many cases an actual check seemed to occur in the rising curve, lasting for some time, followed by an increase of pressure, but at a slower rate than before the check. It was noticeable that the strongest mixtures showed it most distinctly. The hydrogen curves exhibited no such check. It seemed, then, that not only might combustion be incomplete when the vessel was filled entirely with flame, but the pressure at that time might not have attained its maximum, and might continue to increase rapidly after that point. Why did the pressure again increase after the pause in the explosion curve? The author suggested what he considered a sufficient explanation. In an ordinary fire grate, a flame communicated to the coal at one point gradually spread till the whole was incandescent. The solid coal might be every part of it burning, and yet a further accession of air would cause it to glow more brightly—that was to increase in temperature. Explosions have often occurred in flour mills and in coal mines from the diffusion, throughout the air, of minute combustible particles of flour and of coal dust. If present in suitable quantity, a flame applied at one part caused an explosion. It by no means followed, however, that complete inflammation coincided with maximum pressure; the pressure might still increase. In coal gas explosions the flame had filled the vessel before any check occurred, and then the hydrocarbons decomposed, causing a pause, which gave way to increase when the hydrogen and carbon so liberated combined with the free oxygen. In all chemical combinations, dilution caused slowness of action, and dilution during a reaction by the products formed made the last part of the action slower than the first.

Conclusions.—1. Messrs. Mallard and Le Chatelier's theory of increased specific heat of the gases—nitrogen and oxygen—at high temperature was in the author's opinion erroneous. 2. Dissociation probably occurred at the higher temperatures to a considerable extent, but it was not the sole cause imposing a limit to increase of pressure. 3. Combustion was very similar to other chemical actions, the first part of the reaction occurring rapidly, and proceeding with increasing difficulty as the combination approached completion. 4. The explosion vessel was entirely filled with flame before the combustion was complete. 5. The limiting causes acted after the flame had spread completely. 6. The limiting causes in weak mixtures were diminution in the rate of burning as the reaction approached completion, and consequent limits, by cooling. Combustion caused the heat to be evolved at rates greater than, equal to, and less than the rate of cooling.

IMPROVEMENTS IN AIR PUMPS.

THE first improvement to which we will refer is the adjustable connection of the fixed bulb, A, of the air pump with the receiver on one side and with the atmosphere on the other side, by means of the cock, *c*, which is shown clearly in the accompanying cut, taken from the *Zeitschrift fur Instrumentenkunde*. The advantage of this arrangement is that by pouring quicksilver into the cup-shaped enlargement a tight joint is formed.

The second improvement consists of a short tube which is formed opposite the tube, *t*, leading to the receiver, and which is connected by the strong rubber tube, *a*, with the three-way cock, *d*. The cock, *d*, is connected by the flexible tube, *b*, with the movable bulb or vessel, B, and serves to connect B with either the vessel, A, or the atmosphere. This simple arrangement makes the pump, in a certain sense, double-acting, besides offering many other advantages, one of which is that the quicksilver is brought into contact with the elastic tube, *a*, and not with the rigid and breakable glass; and another—which is of less importance—is that a pump of this kind can be used for compression, the only danger being that if a cock is opened carelessly the quicksilver will be forced into the receiver or will be caused to flow from the movable bulb.

GEORGE EDMUND STREET.

THE monumental sculpture in the Central Hall of the Royal Courts of Justice, London, the work of Mr. H. H. Armstead, R.A., is designed to commemorate the architect of that grand public edifice, the late Mr. George Edmund Street, R.A., who died on Dec. 16, 1881, a twelvemonth before the completion and ceremonial opening of the whole pile of buildings.

This monument was lately unveiled by the Lord Chancelor, accompanied by some of the judges. Our illustrations show the design, which is that of a seated statue of the eminent architect, placed on a pedestal of black marble. The pedestal is adorned with a sculpture of groups representing the arts. It also bears an inscription; but one that might not have seemed less appropriate would have been the famous invitation on the tomb of Sir Christopher Wren, in St. Paul's Cathedral, *Si monumentum quæris, circumspice;* for the great Gothic hall, with its characteristic balconies at the north and south ends—the one resting on hexagonal pillars, with twisted volutes; the other supported by massive columns of gray marble, with the noble side arches decorated by Mr. Street's own hand with beautiful stone carvings, the clustered shafts and lofty groined roof—is a work of genius worthy of a great master of this style of art.

It would, indeed, be very beautiful, if the bays and the arches of the balconies could be filled with statuary and the upper wall spaces covered with frescoes of splendid coloring, without which it looks cold and bare. The exterior of these buildings, though wanting apparent constructive unity, presents many admirable features; yet the general effect is disappointing. The Strand front is a complex and studious composition of manifold varieties of English Gothic, ecclesiastical, baronial, and palatial, symbolizing different periods of our national history, the Plantagenet, the Tudor, and Elizabethan, and is thereby significant of the growth of our system of law. The north front, in Carey Street, is stately and elegant. The west side, overlooking what will soon be made a garden, has a rather pleasing effect. The eastern block, striped and mottled with a mixture of red brick and brown stone, is a very singular piece of architecture.

No more difficult task has ever been given to an architect, in our times, than that of the internal arrangement of the Royal Courts of Justice, comprising nineteen Courts, with their numerous offices, sets of apartments, large and small, and separate corridors and staircases for different classes of persons attending these Courts. The essential objects to be attained were to prevent confusion and to economize time in going to every place required, as well as to economize space within the building; and this problem was solved with a fair degree of success.—*Illustrated London News.*

MEMORIAL OF GEORGE EDMUND STREET, R.A., ARCHITECT, IN THE CENTRAL HALL OF THE ROYAL COURTS OF JUSTICE, LONDON.

POMPEIAN PAINTING.

AFTER many careful investigations, Sir M. D. Wyatt arrived at the conclusion that the Pompeian paintings were executed in fresco-secco; but, at the same time, there was mixed with the colors some resin or other material capable of giving them tenacity, and rendering the impasto of the tints glutinous. The plaster upon which the painting was executed consisted of seven coats, exactly as Vitruvius has described them; the first three were of sand, the other four of marble dust, reduced from a fine to a finer texture as each coat was laid on, so that the last coat consisted of the very finest powder. These several coatings were laid one upon another, without allowing any one to dry; the painter then commenced by tracing with the style the principal lines for the ground tints; he then indicated with the same style the figures and arabesques, and then proceeded to paint them in. It will be easily understood that where the painter commenced he found the wall moist, and hence his colors would unite themselves chemically with the lime of the intonaco or plaster, into the pores of which they would readily insinuate themselves. As, however, he proceeded in his work, the wall would continue drying, and hence the amalgamation of the colors with the surface would be less complete. Thus, in the present day, we may easily and clearly discern that certain parts of the wall paintings of Pompeii have altogether detached themselves from the plaster, while in other parts the adhesion has been complete and perfect, although the colors may have been applied in the thinnest possible state. Those portions of the wall which have lost their colors furnish a strong argument in support of these conclusions, since the scratch of the style which served to indicate the grounds, and give the main outlines of the arabesques and figures, was evidently made upon the wall while it was yet wet, and while the plaster was, consequently, in a soft condition. Wherever the color has flaked off, the strokes of the style appear clean, precise, and most exact. If, as has been alleged, the paintings of the ancients had been made on a dry wall, it is certain that the strokes of the style could never have left a clean line, but would rather have shown a jagged or broken one, unequal in the depth of the various parts of the incision; this must necessarily have been the case with plaster presenting so hard a surface as that composed of marble dust. He is supported in this opinion by observing that where the painter has desired to produce an extraordinary effect, he has cut out the plaster and inserted a new piece in the middle of the wall, and upon that has executed his picture. Had it been the custom of that period to paint on dry walls, there would have been no reason for such a renovation, nor should we, says the editor of the *Architect* (London), have been enabled to account for so curious a process.

SIZE OF STONES IN MASONRY.

IN many edifices, both ancient and modern, it has been observed that the stones used were too thin, viz., that they had not sufficient thickness in proportion to their length, and that in consequence they broke under the weight. These accidents arose from the stones not resting equally throughout the whole surface of their beds, either because these surfaces were not exactly dressed or leveled, or because some unequal settlement took place which deranged the lower stones.

The greater the thickness given to stones relative to their length, the greater is the power of resisting this effect, which it is often very difficult to foresee or prevent. For works which have very great weights to carry, such as walls and points of support, cubes are the strongest, but they have less stability, and do not form sufficient bond; those in which the length is much greater than the height have more bond, but less strength to carry the weight. According to the experiments made on stone, the length may be fixed at from twice to thrice their height, and their width from once to twice, supposing the stone of a moderate hardness. When the stones are very hard, more than a foot thick and wrought on all sides, their length may be from four to five times their height, and their width from two to three times. Larger dimensions increase the expense, but not the utility.—*E. Cresy.*

NATIONAL AGRICULTURAL HALL, KENSINGTON.

THIS building, now rapidly approaching completion at Kensington, London, presents several novel features, to which we draw the attention of our readers in the present and a subsequent article. The site is on the western side of Addison road station, on ground hitherto occupied by market gardens, which from its contiguity to the railway and to the main road from Piccadilly to Hammersmith offers considerable advantages for any place of public resort. The idea of the promoters is that there is great need for a building affording a large covered space for spectacular displays, horse shows, and exhibitions, and that the Agricultural Hall at Islington, which is at present the only building in London available for the purpose, is quite insufficient and not conveniently situated.

The late Mr. H. E. Coe was the architect who, from the first inception of the scheme, prepared the designs, the general arrangement of the various buildings, as well as the fine elevation adjoining the railway, being due to him. Mr. Coe died just as the building operations began, and the completion and control of the work has been intrusted by the directors to Mr. J. Edmeston, architect. The most important part of the building is the main hall, and Mr. Coe in regard to this consulted Mr. M. Am Ende and Mr. A. T. Walmisley, engineers, both of Westminster, and the roofs, screens, galleries, with the various works depending on them, have been designed by these gentlemen. We illustrate the general arrangement of the roof over the main hall, which is 440 ft. long by 250 ft. wide, the center span being 170 ft., or 45 ft. more than that at the Islington Agricultural Hall. The crown of the center roof is about 110 ft. from the floor, and the roof ribs, having no horizontal ties, have a horizontal thrust. As will be seen from the cross section, there are no masonry abutments, the outer walls serving only as screens and to share in carrying the gallery floor. Abutments are ingeniously provided at each roof principal by an iron framework, indicated in the engraving. The raking roof girders over the gallery transmit the horizontal thrust of each main central rib to a frame which, commencing about 12 ft. above the gallery floor, extends downward 10 ft. into the ground and terminates under the bases of the columns. The main ribs are 7 ft. deep by 2 ft. wide, of a lattice form, as shown in the engraving, and they are placed 34 ft. apart, with purlins and intermediate rafters forming a framework between.

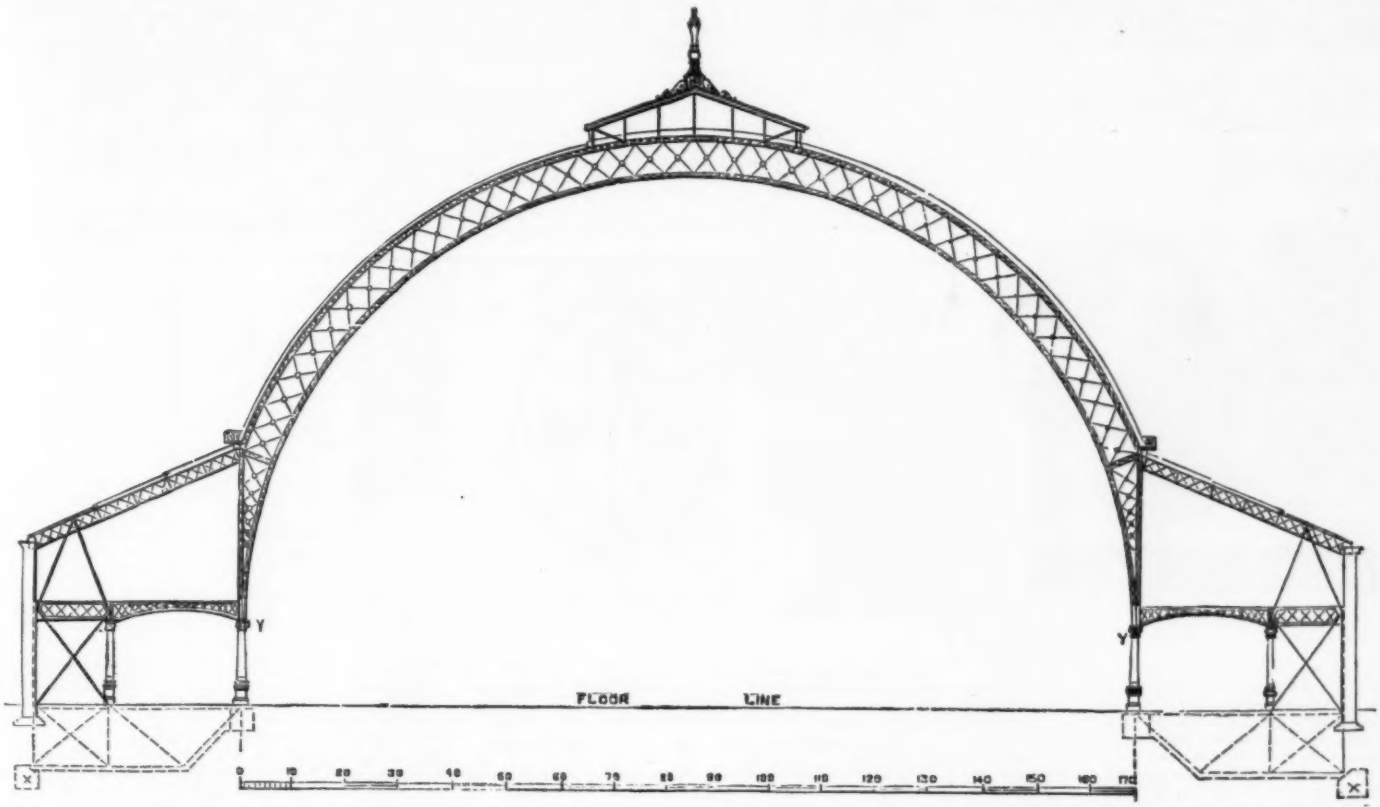
The greater part of the vertical weight brought on to the main rib is transmitted through the springing pieces, and thence through the columns to the termination of the frame before mentioned. In order to avoid any bending moment from the rib or from the gallery girders, the columns are pivoted at top and bottom, as shown in the engraving, thus insuring that the strain shall in any case pass through the axis of the column.

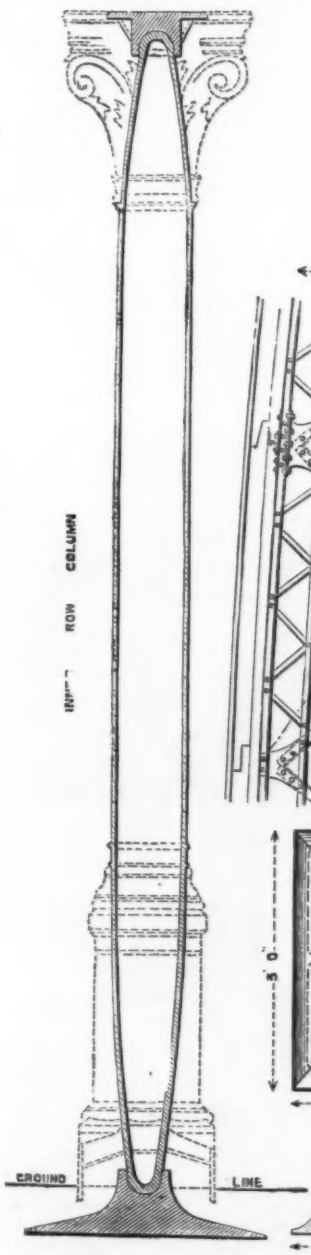
Speaking generally, the iron structure is remarkable for its extreme lightness, due, not to any sacrifice of strength, but to the skill with which the various parts are disposed and to the arrangement of the bracing. The contractors for the building are Messrs. Lucas & Son, of Kensington Square, and the ironwork is being made and erected by Messrs. Andrew Handyside & Co., of Derby and London.

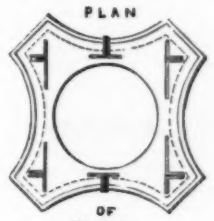
FLOWERING plants may be kept over winter by packing their roots in a box of sand in a cellar.

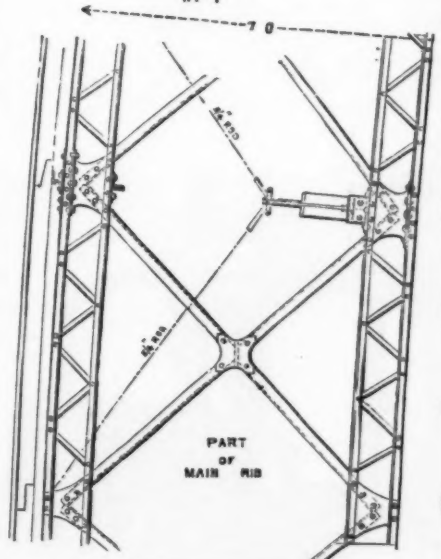
THE NATIONAL AGRICULTURAL HALL, KENSINGTON.

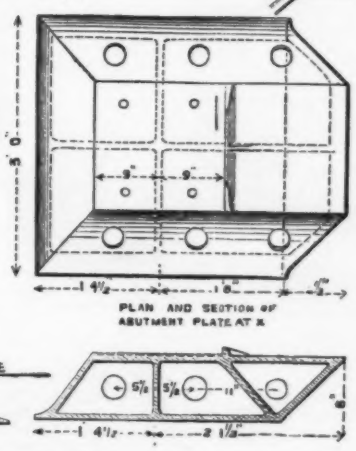
H. E. COE, ARCHITECT; MAX AM ENDE AND A. T. WALMISLEY, ENGINEERS; MADE AND ERECTED BY ANDREW HANDYSIDE AND CO., DERBY AND LONDON.

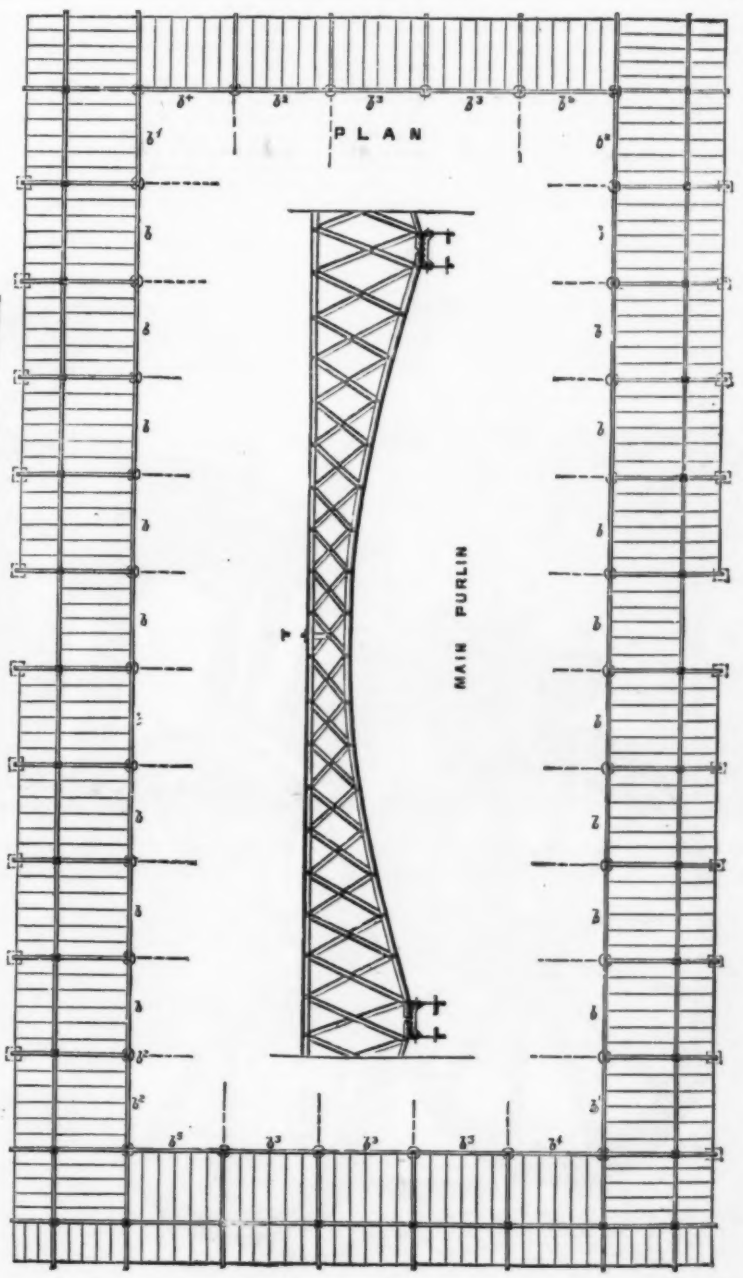












COLUMBUS' EGG.

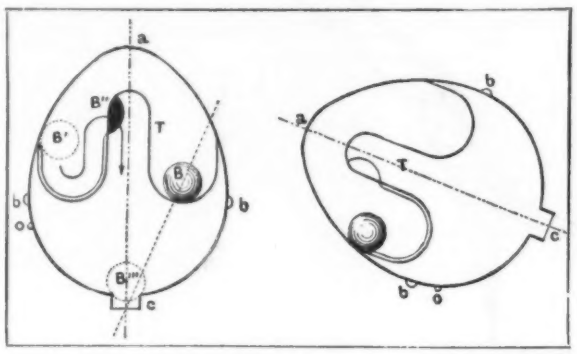
THE accompanying engravings represent an object which is being sold in the London bazars at a very moderate price. It is made of tin, is painted red, and is called "Christopher Columbus' Egg," because those who do not know how it is constructed cannot make it stand up on the projecting part situated at the base. This egg, which it is impossible to open, is hollow, and contains a leaden ball which causes it to fall over on its side, unless it (the ball) is in the longer axis.

The sections in Figs. 2 and 3 explain the construction, and show how the ball is brought into the desired position to cause an equilibrium.

FIG. 1.—COLUMBUS' EGG.

Corresponding to the point where the two halves of the egg are soldered together, there is internally a partition that has the form of a channel of semicircular section which runs around the tube, T. The ball, B, when the egg is held vertically, is capable of revolving around this tube, T, and, as long as it remains in the channel, will cause the egg to fall every time the operator endeavors to make it stand on its base, C. The egg can stand upright only on condition that the ball be made to pass from the upper to the lower compartment, in which case it will take the position, B''', at the base of the egg. This result is reached as follows: The central tube contains, just beneath its upper extremity, an aperture, B'', that forms a communication between the two compartments, and that is sufficiently large to allow the ball to pass through. Two small guides start from the side of the egg, and follow the contours of the partition up to the orifice in the central tube. On a line with the orifice, and on the outside of the egg, there is a small and scarcely visible point, *o*. If the egg be sufficiently inclined toward this latter, as in Fig. 3, the ball will take the position, B, at the beginning of the guides leading to the orifice, B''. If, at this moment, the egg be gently turned back in the opposite direction, the ball, being kept in the plane formed by the point, *o*, and the egg's axis, will run along the guides and drop through the orifice into the lower compartment. When the egg is righted, the ball will take the position, B''', at its base, and the egg will then stand upright. By turning the egg upside down, the ball may be made to enter the upper compartment again, and things will then be as before.

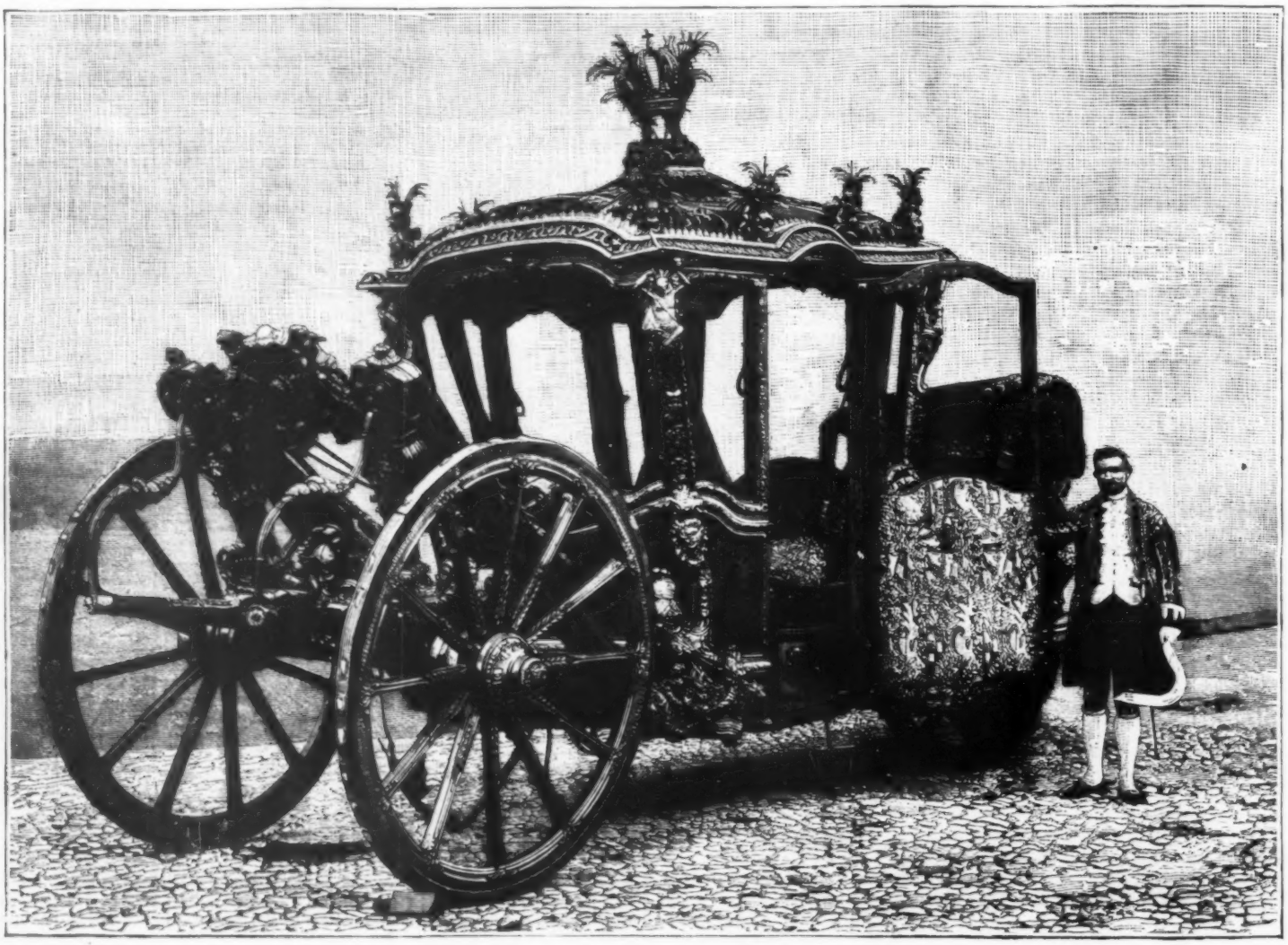
With a little practice and skill, it is not even necessary to look for the position of the point, *o*, and thus run the risk of showing the uninitiated how the trick is done. On giving the egg a slight angular motion, the hand will feel the passage of the ball over the slight projection formed by the guides; the ball will naturally seat itself upon the latter, and the double motion above mentioned will accomplish the desired result. Effected in this way, and the hand being covered with a handkerchief, the mode of operating will not be perceived by the uninitiated spectator.—*La Nature.*



FIGS. 2 AND 3.—DETAILS OF CONSTRUCTION.

THE PORTUGUESE ROYAL CARRIAGE.

WE give an engraving made directly from a photograph of the celebrated royal carriage of Portugal, which has been carefully preserved, and is now in good running order. It belongs to the precious possessions of the King of Portugal. This carriage was built in the time of the illustrious monarch Don Juan V., who began his reign in the year 1705, and continued to govern with discretion and prudence for forty-five years. The ancient vehicle was constructed in the highest style of both decorative and practical art, being made even stronger than "the wonderful one-hoss shay," which "ran for a hundred years to a day." The Portuguese carriage is more than a hundred and fifty years old, is in fine condition, and is still used in all grand processions of the court. It is so strong in every part that it can't break down, and no earthquake shock has, as yet, done it an injury. We are indebted for our picture to *La Ilustracion Española.*



THE PORTUGUESE ROYAL CARRIAGE.

THE ACTION OF METALS ON ACIDS.

By HENRY E. ARMSTRONG.

OUR knowledge of the nature of alloys is at present very limited. It is supposed that some metals are capable of combining, but that others form mere mixtures when fused together, the alloy being, as it were, "a solidified solution of the one metal in the other." This differentiation is based on the study of physical properties of alloys in comparison with those of the constituent metals. In certain cases—but these are very few in number—the actual composition of the compound may be deduced. Thus, in the case of the tin-copper alloys, abrupt changes in electrical conductivity correspond to compounds of the formula $SnCu_4$ and $SnCu_3$, and the curve of conductivity for the tin-gold alloys also exhibits a striking series of maxima and minima, from which the existence of definite compounds may be inferred. It appeared possible that, by dissolving alloys in a liquid capable of acting on both metals, and determining the electromotive force between the alloy and a less positive metal, evidence of the existence of definite compounds might be obtained if the alloy dissolved as a whole. At Dr. Armstrong's suggestion a number of determinations of this kind have been made by Messrs. Holland Crompton and W. E. Sumpner, students of the Central Institution, but the investigation is as yet far from being completed. They have measured the E.M.F. between the alloys and platinum in nitric acid by means of an electrometer. The general result is that the method is inapplicable, since the alloys do not as a rule behave as wholes. The E.M.F. observed in several cases is very nearly that between the less positive metal of the alloy and platinum, the more positive constituent dissolving independently and giving rise to a local circuit. Thus, in the case of copper-

zinc alloys the E.M.F is very nearly that of copper as long as the alloy contains not much less than about 5 per cent. of copper; the tin-zinc and tin-copper alloys also have an E.M.F. near to that of the less positive metal until alloys are reached containing but a small proportion of this constituent. In mercury-zinc alloys the more positive metal determines the electromotive force; this apparently is also true of the lead-tin alloys. Slight changes have been observed which, if confirmed by further experiments, are probably significant; thus in the tin-zinc alloys the E.M.F. gradually rises from that of tin as the amount of this metal in the alloy diminishes; it is conceivable that this may be because the zinc acts as a diluent, and separates the more complex tin molecules into simpler more active molecules. On the other hand, the E.M.F. of copper in bronze is slightly lower than that of pure copper, and that of copper in the copper-zinc alloys rich in zinc is also a little lower than that of pure copper; this may be due to the loss of energy in the formation of the alloy.

Dr. Armstrong then pointed out that although the method described was of little value, owing to the irregularity in the behavior of alloys toward a solvent capable of attacking both metals, more was to be hoped from the employment of a solvent capable of acting upon only one, recent experiments by Mr. Laurie having shown that the E.M.F. between zinc-copper alloys and cuprous iodide in a solution of iodine and zinc iodide is about that of zinc until the alloy has the composition $CuZn_5$, when the E.M.F. suddenly falls to very nearly that of copper. Sodium and potassium exhibit a much lower E.M.F. when alloyed with mercury, according to Hockin and Taylor, and it is probable that the examination of a graduated series of their amalgams will afford indications of the composition of the compounds formed.

The E.M.F. between a given metal and platinum in nitric acid varies with the concentration of the acid. The following results were obtained with copper:

		Volt.
Acid of rel. den. 1·5	E.M.F.	0·98
3 vols. 1·5 + 1 vol. 1·42	"	0·84
1 vol. 1·5 + 1 vol. 1·42	"	0·63
1 vol. 1·42	"	0·57
1 vol. 1·42 + 1 vol. water	"	0·75
1 vol. 1·42 + 3 vols. "	"	0·81
1 vol. 1·42 + 7 vols. "	"	0·81

These results appear to be entirely confirmatory of the conclusions already arrived at by Ackworth and Armstrong (*Trans.*, 1877), who found that the reduction of nitric acid was carried further—as indicated by the amount of nitrous oxide and nitrogen produced—when copper is dissolved in highly diluted nitric acid. The high E.M.F. observed on using the most concentrated acid is probably due to the fact that the initial product of reduction, nitrous acid, remains in solution. If the acid be less concentrated, the nitrous acid is more or less broken up:

$$(3HNO_3 = 2NO + HNO_3 + H_3O).$$

The considerable rise in E.M.F. as dilution proceeds not improbably arises from the complex molecules of nitric acid being in part resolved into simpler more active molecules. The results also illustrate the importance of supplementing the chemical method of examining complex cases of change, such as are involved in the action of metals on nitric acid by the electrical method. No appreciable action takes place during the time requisite to measure E.M.F., and therefore the solution remains practically unchanged in composition, whereas it is continuously changing during the entire course of a chemical experiment.

Referring to the action of metals generally on acids, Dr. Armstrong pointed out that it is probably impossible for the chemist to pronounce definitely in favor either of the modern view that the metal directly displaces the hydrogen of the acid, or of the older view that the metal displaces the hydrogen from water—the resulting oxide and the acid then interacting to form a salt; the decision of this question must apparently depend upon the determination of the nature of the phenomena during electrolysis of an acid solution. If the acid alone be the electrolyte, then doubtless the modern view is the correct one; but if both water and acid are electrolyzed, and in proportions which vary according to the conditions, then both the old and new view of the nature of the action between a metal and the solution of an acid are correct, and the two kinds of change may go on side by side. The view put forward by Dr. Divers, that silver, copper, and mercury exercise an altogether peculiar action on nitric acid, "decomposing the nitric acid into hydroxyl and nitroxyl, and combining with these radicals to form hydroxide and nitrite, which by secondary reactions become water, nitrous acid, and metal nitrate," does not appear to be compatible with the view that the interaction of a metal and an acid is essentially a case of electrolysis, there being no reason to suppose that nitric acid can be electrolyzed into hydroxyl and nitroxyl; it is not supported by the observations here described on the E.M.F. of copper in acids of various strengths, which show that more depends on the state of the acid than on the metal; and, lastly, silver is incapable of acting on nitric acid, although it readily enters into interaction with the weaker electrolyte, nitrous acid.—*Pro. Chem. Society.*

FACSIMILE TELEGRAPHY.

MOST of the facsimile processes come under the head of chemical telegraphs, and are based upon the decomposition of a solution, usually of iodine, by the passage of a current. They all require special apparatus of a more or less complex nature, and hence are not adapted for every day rough-and-ready work. Recently, however, Lieutenant Glen and Lieutenant-Colonel Melville, of the English army, have independently hit upon an ingenious system by which the ordinary operation of telegraphing may be made to serve the purpose of reproducing sketches and plans. Strictly speaking, the system is not a facsimile in the true sense of the word; but by its means very fair reproductions can be obtained, and its value in some situations and circumstances may be considerable. The method consists of either drawing the design to be transmitted on ruled paper, divided into little squares by vertical and horizontal lines, or laying a transparent paper, tracing cloth, or other transparent sheet, which must be so divided by lines into squares, over the drawing. The squares in each compartment, as shown in Fig. 1, are denoted, respectively, by pairs of letters, the alphabet running down the outer side for the horizontal rows of squares, and along the top for the squares in vertical series. A corresponding paper, which may be of a different scale if convenient, is kept at the receiving station. The operator at the transmitting station can thus indicate by alphabetical letters to the receiving station any point on the paper falling in the center of any of the squares; the person at the receiving station will apply his pencil to that point, and will then be directed to the next point, drawing a line with the pencil, and so on to form a complete outline drawing.

Figs. 2 and 3 show fancy portraits, the one being the original, the other the transmitted copy.

Patches of shading, of the several darker or lighter tints shown in Fig. 4, may be put in by special direc-

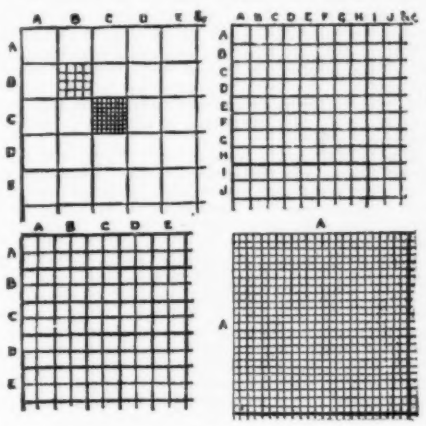


FIG. 1.

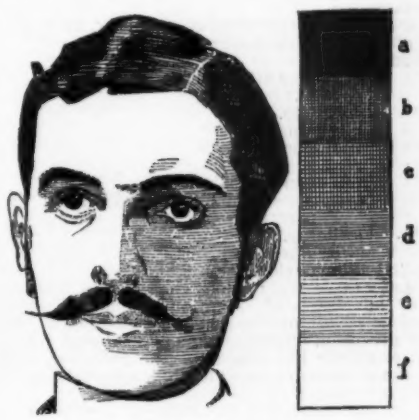


FIG. 4.

tions, the transmitting signs for which must be preconcerted.

Paper ruled with squares of any size, large or small, may be used according to the purpose and nature of the drawing; but in the "sectional paper" adopted by one of the inventors, the parallel ruled lines are set one-eighth of an inch apart, giving sixty-four little squares to one square inch. Where greater minuteness of delineation is required, there is a way of getting several exact points within each little square, as well as its central point. This is obtained by setting two additional letters, instead of one letter only, at the head of each vertical column of squares, and at the end of each horizontal row of squares, practically subdividing each square into four. The sender of the message, when the drawing is so large as to extend over a number of quadrangles, must apprise the recipient of it which is the particular quadrangle or division of the paper that he has in hand; but this is easily done by prefix signal letters. The scale of the map or plan is also to be stated, which will suffice to the recipient for learning the measurement of all distances within the plan.

FIG. 2.

FIG. 3.

We refer those who desire a more minute description to the April quarterly publication of the Journal of the Royal United Service Institution.

HISTORY OF THE ELECTRICAL ART IN THE UNITED STATES PATENT OFFICE.*

By C. J. KINTNER.

I ONCE heard a member of Congress say to some of his constituents who were doing Washington city, from the tourists' standpoint: "Go first to the Smithsonian Institution, where you will see all that God ever made; go thence to the Patent Office, where you will see all that man ever made."

This advice, although given in jest, contained, at least so far as the Patent Office is concerned, much more truth than the speaker imagined.

The American patent system virtually dates its origin from the Constitution, in the eighth section of the first article of which our forefathers inculcated these words.

"Congress shall have the power to promote the progress of science and the useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

Out of this grew legislation concerning patents as early as 1790, when the first revised statutes became law.

No organized system of granting patents was developed until 1836, when the Patent Office sprang into existence, and the law was amended so as to develop substantially the system in vogue to-day. From that time to the present, just a half a century ago, there have been no material changes in the revised statutes, and there has resulted from this wise legislation the most wonderful advance in the arts and industries the civilized world ever knew.

I am invited to address you to-night, upon the historical electrical apparatus of the United States Patent Office.

You will pardon me if I broaden the scope of my remarks to such an extent as to include or make them commensurate with the growth of the electrical art as developed in and by our patent system.

In the Patent Office we recognize and protect by patent all inventions and discoveries coming under any one of the following classifications: (1) an art; (2) a machine; (3) an article of manufacture; and (4) any improvement upon any one of the foregoing.

The limited time at my disposal will not permit me to give definitions of these statutory classifications, so I will simply indicate to you that the Patent Office recognizes about twenty-four classifications in the arts, beginning with the oldest art known to man, agriculture, following with the arts of textiles, metal working, etc., and ending with the youngest and to us the most interesting—electricity. Each of these arts is divided into classes and each class into sub-classes for the convenience of search and for the sake of an orderly arrangement of the records in the office.

One principal examiner has charge of each art, and is supplied with from four to eight assistants, dependent upon the demand of his art.

The electrical branch of the office prior to 1881 embraced one sub-class known as Class 36, Electricity, under the Division of Philosophical Instruments. In that year the rapid growth in the matter of electrical inventions made it necessary to make a new classification, and philosophical instruments were taken by another examiner, electricity constituting an entire class, which has since become the most important art in the Patent Office.

The introduction of the telephone, based upon Alexander Graham Bell's patent, No. 174,365, March 7, 1876, gave a new and wonderful impetus to inventions in electrical appliances. There had been prior to that time marked progress in telegraphs, and much ingenuity had been displayed by inventors in simplifying the methods of telegraphic communication by developing apparatus adapted for use between inexperienced operators by automatic, stylographic, and printing telegraphs; but when this new and wonderful invention sprang into existence, it seemed to instill new life into the inventive genius of the world. Prior to 1876, less than 2,000 patents had been granted on electrical appliances of all kinds.

So rapid has been the development that each year necessitates new classification, and a thorough reorganization of the entire classification was effected during the past year, creating in place of one class, nine, as follows:

Class 171, *Generation.*—Embracing all kinds of apparatus for the generation of electricity.

Class 172, *Motive Power.*—Including electric motors, transmission of power, etc.

Class 173, *Conductors.*—Including all means of conveying electricity from point to point, and all apparatus for in any way facilitating the transmission of current without interruption.

Class 174, *Medical and Surgical.*—Including all applications of electricity for sanitary purposes.

* A lecture delivered before the Franklin Institute, January 25, 1886.—*Franklin Journal.*

Class 175, *Special Applications.*—Having reference to all miscellaneous applications of electricity, such as are found useful in other arts, as dyeing, tanning, machinery, etc.

Class 176, *Electric Lighting.*—Having reference to all uses of electricity for illuminating purposes.

Class 177, *Signaling.*—Including all devices used for transmitting indications or alarms and signals for specified wants or needs, as burglar alarms, annunciators, railroad signals, etc.

Class 178, *Telegraphs.*—Including all methods and apparatus for transmitting information by codes.

Class 179, *Telephony.*—Embracing all appliances utilized in the transmission of articulate speech, whether by electricity or mechanical telephones.

Each of these classes is again divided into sub-classes as the necessities of the case may warrant, so that under the existing classification there are found about 100 sub-classes.

Take as an example the class of telephony, in which we recognize twelve sub-classes, as follows:

Telephones, calls.
" details or attachments.
" electric.
" magneto.
" mechanical.
" radiophones.
" reed.
" relays and repeaters.
" systems, embracing central station apparatus.
" switches.
" switch-boards.

And anti-induction devices.

Each assistant examiner has charge of a definite number of sub-classes of invention, and he makes the examinations of all applications appertaining to the classes of invention under his immediate charge. The principal examiner has charge of the entire art, and supervises and passes upon all matters appertaining to the granting of patents in his particular art

As at present organized, the force of the electrical division embraces one principal examiner, eight assistant examiners, three clerks, and one stenographer. Some idea may be had of the amount of work done by this force by examining my late annual report to the Commissioner of Patents, from which I note that there were filed, during the year, 2,019 new applications; there were filed 3,679 amendments calling up old or rejected cases for further action; here were granted 1,320 patents; there were made 6,036 actions upon all kinds of cases; and there were abandoned by act of law 610 allowed cases.

With this very brief insight into the general method of doing business in the Patent Office, we are prepared to review the art from its earliest inception.

It is a remarkably strange fact that in this, the youngest of the industrial arts recognized in the Patent Office, very few of the earlier inventions which note great advances were ever patented in this country.

We find that many of the very best batteries known in the art were the result of laboratory experiments made by such physicists as Grove, Bunsen, and Daniell, and were never made the subject of patents in America.

So, too, with the earlier friction generators; the broad principle of reactionary generators discovered by Hjorth, and the broad idea of the division of the arc light as developed by Messrs. Lacassagne and Thiers as early as 1856.

We note also that Starr King, of Cincinnati, O., took English patents for the broad idea of an incandescent lamp with continuous conductor in an exhausted globe as early as 1845, but never patented in America.

It seems remarkably strange that this should be true, and I can only attribute as a reason that it is a generally acknowledged fact that men of science seldom patent their discoveries.

Many of the best inventions made known to the world have been donated by men of science to the public, and apparently for the reason that the scientist seems to be so deeply engrossed in his labor of love, to which he devotes his whole soul, that he cares for little else than the gratification which his researches bring to him and his fellow laborer

It is particularly gratifying to us that this mysterious art comes within the domain of the scientist, and that such scholars as Faraday, and Ohm, and Ampere, and Varley, and Thomson, and Clerk Maxwell, and a host of others were and are its acknowledged patrons.

In treating a subject relating to the history of an art extending over a period of half a century, and embracing a matter of 10,000 patents, I can, of course, only touch here and there upon such matters to-night as note matters of interest or marked steps in the art, and I will note the progress chronologically, rather than by assuming to discuss any particular phase of the art extending through that period of time.

The records of the Patent Office show that the first patent disclosing any electrical appliance whatever was granted in 1833, July 23, to D. Harrington, of Philadelphia, Pa., for an apparatus for curing diseases by electricity.

Strangely enough, we here find a native of the dear old city of Brotherly Love at the very threshold of an art displaying that commendable spirit of philanthropy for which her citizens have been noted since the days of Penn, and seeking by this new and wondrous art to extend the hand of brotherly love to a suffering companion.

However commendable the inspiration may have been which led Mr. Harrington to thus offer aid to his suffering fellow men, I cannot vouch for the efficiency of his apparatus, which consisted in applying two metals of different electrical potential to the body in such a manner as to generate an electrical current through the body.

I am of the opinion that no very gratifying results would be attained from its use unless it be assumed, as is often the case with this class of inventions, that the patient is to be blessed with a very large endowment of faith.

Mr. Harrington took out two more patents on apparatus of a similar nature in the following years, 1834 and 1835.

These three patents are all that are found upon the records in the art prior to the establishment of the Patent Office proper in 1836. The original records of them were destroyed in the great Patent Office fire of 1836.

The first patent granted under the revised law of 1836 was to Thomas Davenport, of Brandon, Vt., for an electro-motor, on the 25th of February, 1837.

The motor is a curious relic, and although meagerly described, I will endeavor to give you a clear understanding of it, obtained from a study of the model and the specification.

The armature consisted of four axial magnets attached to a wooden wheel supported by a vertical shaft.

The winding of these magnets was continuous from one to the other, and the commutator brushes had their bearing on segmental strips, equal in number to the number of electro-magnets.

The field magnets, two in number, were arranged concentrically about the armature, and were composed of permanent magnets. It was not dissimilar in its action to the well-known Gramme machine.

On the 27th of June, 1838, the first derived circuit motor was patented to N. Walkly, of Tuscaloosa, Ala.

This motor, like that of Davenport's, had an armature with axial magnets attached to a vertical shaft. The current was reversed through the armature at each half revolution by an eccentric and commutator springs analogous in their operation to the valve mechanism of a steam engine.

The field magnets were energized by a derived circuit flowing always in the same direction from the battery.

It possessed many remarkable features found in the best types of electric motors of to-day, and probably failed in its efficiency only because of its clumsy commutator action.

Following closely upon the heels of the Walkly motor came the Stimpson motor, patented on September 12, 1838. It is not dissimilar in its general appearance to the well known Alliance magneto machine, and consists of an armature composed of a series of magnets arranged parallel to the revolving shaft which carries them, and so that both poles of these magnets shall be exposed to opposing field magnets located in planes parallel to their ends and radially fixed with relation to the revolving axis. The commutators were arranged in a manner not unlike the well-known Gramme commutators, and the current was commuted through the armature magnets successively as they came into the effective field of the field magnets, which were charged by an additional battery.

At this stage of the history of the art, there comes upon the scene of action the first inventor of lightning rods, who seems to have availed himself of the protection offered inventors by our patent system. Whatever may have been the merits of his invention, and whatever success he may have attained with his patent, there can be no question but that he, Joseph S. Barber, of Gloucester, Mass., deserves at least a passing mention in order that the rural communities of this great country may know to whom they are primarily indebted for the annual precipitation of lightning rod literature and persuasive eloquence in behalf of an assured protection from the ravages of one of Nature's most destructive elements.

This, the first patent upon lightning rods, was granted March 6, 1839, and to one versed in the peculiarities of statical electricity, the invention covered by it appears somewhat peculiar, and I may add, to be of doubtful utility. It consisted of a paraboloidal metal body, having its base attached to a wooden rod, the latter fixed at some elevated position above the structure to be protected.

Affixed to this paraboloidal body were several sharp points of metal projecting in all directions about it.

The inventor assumed that when a storm cloud approached, this metal shield would cause the bound electricity in the structure to be disseminated before the cloud reached a striking distance.

I do not know if the inventor ever located himself in a building so protected or, perhaps I should say, so exposed. Inasmuch as nothing is known of his future success, and the records show nothing more in his direct line of invention, I take it that it is entirely probable he did try it, and with such a gratifying result to the public as might readily be expected, viz., total annihilation.

It is pretty generally assumed on the part of our countrymen that Prof. Morse was the first to patent the electric telegraph in this country.

This is a mistaken notion, as the records of the Patent Office show that Messrs. Wheatstone and Cook, of England, took a patent for their needle electro-magnetic telegraph on the tenth day of June, 1840, while Prof. Morse's patent followed only ten days later.

The Wheatstone and Cook needle apparatus consisted of several wires running to the distant or receiving station, in each of which was located a galvanometer adapted on closure of the circuit to cause a needle to vibrate to the right or left as desired.

It was necessarily cumbersome, and never found a place among the practical inventions of the art in this country. It stands upon the records only as one link in a chain of historical apparatus.

This patent also embraces some features upon underground conduits, which are of general interest at present in view of the attempts to force conductors under ground.

It was primarily to Morse's apparatus, based upon his code of signaling and the use of a single line wire, with his well-known recorder, that we owe success in telegraphy. So well known is Prof. Morse's invention that it is not necessary to offer any description here, but simply to note that the original models on file in the Patent Office take the first rank among such historical curiosities as the Howe sewing machine, the Jacquard loom, etc.

It is very curious to note also that the models made by Prof. Morse are marvels of workmanship and proportion when we consider the fact that he was pioneer in the art, and labored under difficulties known only to a great inventor struggling against fate.

In 1842, March 28, the first patent was granted to Patrick Coad, of Philadelphia, Pa., for an improved galvanic battery for medical uses.

It appears as though the early history of the art looked entirely to your city for those men of genius who should devote their efforts in behalf of the afflicted. This invention notes only an improved manner of immersing the plates of a battery in a cell so as to indicate the quantity of current, and also an improvement upon the electrodes used by the patient.

It is of no especial importance other than being the first galvanic battery protected by patent in America.

In 1846, April 11, we find the first printing telegraph patent granted to Royal E. House.

It consisted of a key-board having keys controlling the rotation of a power impelled cylinder, which in turn controlled the operation of a circuit breaker in the telegraph line, extending to a distant receiving station, where was located a power impelled type wheel, controlled by an electro-magnetic escapement.

This application, which was the parent of a large class of inventions known as printing telegraphs, was followed in 1848, December 5, by Bain's automatic telegraph, which was designed to avoid the Morse patent heretofore referred to. It operated by or through the agency of an electrical current acting upon a circuit upon a paper made sensitive by a chemical solution. Out of this patent grew the famous suit, O'Reilly *vs.* Morse, in which the Supreme Court of the United States held Morse's eighth claim, which was in effect to the use of electricity for the transmission of intelligence, to be void.

The first patent upon a straight current magneto-electric machine bears date of November 1, 1853, and was granted to Calvin Carpenter, of Pawtucket, Mass. It is substantially an Alliance machine with commutator arrangement for straightening or directing the current; the armature consists of a series of electro-magnets whose cores are exposed at both ends to the influence of permanent magnets arranged in front of them. The commutation of current is not substantially different from that in general use on this type of machines as now used.

I will now call your attention to the Page motor, patented by Prof. Chas. G. Page, on the 21st of January, 1854. In this motor the two armatures consist of long cores of iron which are adapted to slide with an oscillatory motion through two pairs of solenoids made up of successive sections, which are brought into action by sliding commutators actuated by rods from eccentrics on the fly-wheel shaft, being entirely analogous to the cut-off mechanism used in a steam engine.

It was not, however, a practical motor, nor is any motor, so far as I can ascertain, which depends for its action upon shifting commutators actuated by eccentrics, for the reason that the element of friction is above the mean.

This motor is the more interesting to us because its inventor was an acknowledged authority in electrical matters in his day, was the associate of Prof. Henry, and the discoverer of what is known as the Page effect in the cores of electro-magnets. He was also one of the first examiners appointed in the United States Patent Office under the law of 1836.

On the 18th day of May, 1858, Messrs. Collier and Baker took out the first patent granted by the United States for an improvement in the arc light.

It consisted of two electrodes of carbon; the upper carbon was prevented from contact with the lower by a retaining diaphragm of metal through which its point projected.

It acted by a mercurial feed, the carbons being forced forward by the mercury in which they were immersed. As a practical lamp, it was not a success.

By a strange coincidence, during the same year the first patent upon an incandescent lamp was issued to Gardner and Blossom, composed of a platinum coil inclosed in a glass chamber, but this containing chamber was not exhausted.

This lamp was of course not practical. This year was also productive of the first successful duplex telegraph, invented by M. G. Farmer, and also what is known in the art as the Hicks telegraph repeater, for transferring messages to successive lines.

In 1859, on the 20th of September, the well known Grenet battery was patented.

On the 26th of February, 1861, there was patented to Charles Kirchoff, of New York, an improvement in storage batteries which deserves special mention here. It stands out alone to-day as an invention at least twenty years in advance of its time, and the description and model are wonders of curiosity to those dealing with the question of storage batteries.

I venture to say that no one of the older patents in the art has been more generally quoted and appeared in the light of an annoying reference to those who imagined they were original inventors than the one under discussion.

It is of the Plante type, composed of lead plates adapted to be charged as was Plante's battery. Kirchoff saw the necessity of increased surface for his electrodes, and to this end proposed many forms, consisting of corrugated plates, wire netting, perforated plates, etc. He well understood the necessities of the case, and his specification discloses a knowledge of the art at once as wonderful as was his ingenuity in developing means of overcoming to him known difficulties.

He also developed an apparatus for charging each cell in succession while the charged cells were discharging upon an exterior working circuit.

I regret that I have not the model with me to show you the wonderful genius of an inventor who was developing an art destined to sleep nearly twenty years.

The next improvement in this line of invention was patented to C. G. Percival, of Brooklyn, N. Y., on November 9, 1866. It consisted of a wooden battery cell divided into two chambers by a porous partition. In these chambers was placed powdered carbon or lead in such manner as to surround the electrodes.

This carbon or lead was saturated with dilute sulphuric acid, after which it was ready to receive the charge. This is the first storage battery having active material surrounding the electrodes.

On the 23d of April, 1867, a patent was issued to G. S. Leclanche for the famous battery now found with slight change in almost every telephone box in the land. It is too well known to need description here, and stands as a landmark in the list of useful inventions covered by patents.

I come now to an important invention by Prof. Page, covered by patent No. 76,654, April 14, 1868, and afterward reissued on the 10th of October, 1871, by Prof. Page's assignees, the Western Union Telegraph Company, in such broad terms as to include all telegraphic apparatus wherein a main circuit is caused to operate or control a local circuit, and also the use of a retractile spring to an armature of an electro-magnet.

This is the famous Page patent, so long held by the Western Union Telegraph Company as a menace over he heads of other telegraphic corporations.

It consisted of the well-known form of induction apparatus with an automatic circuit breaker, and was invented by Prof. Page many years before he took a patent, which was granted by virtue of a special act of Congress, he being an officer of the United States Patent Office, and therefore disqualified by law to take an interest in any United States patent except by inheritance or bequest.

This patent expired April 14, 1885, and thereby opened wide a great field, although it is extremely questionable if the reissue could have been sustained in its broadened aspect in view of modern Supreme Court decisions touching the question of broadened reissue patents.

We now note the appearance of the first double type wheel printing telegraph, patented to E. A. Calahan, April 21, 1868, and reissued to the Gold and Stock Telegraph Company, on the 25th of July, 1870.

This instrument was the first to utilize double type wheels, one of which printed letters and the other figures.

It has since passed into the hands of the Western Union Telegraph Company, and suit is now pending between said company and local printing telegraph companies in New York city for infringement of its claims.

An interesting invention is found in a patent to two Frenchmen, Messrs. Chauvassaignes and Lambrigot, bearing date of July 28, 1868, wherein the message to be transmitted was marked in non-conducting ink upon a metallic tape designed to act as a transmitter by which the circuit of a telegraph line was broken and closed, and the message was recorded upon sensitized paper at the receiving station. Inasmuch as the rapid telegraph companies are using this invention as embodied in more improved apparatus to-day, this invention notes an early stage in an art then quite undeveloped.

I desire now to call your attention to an invention by one whose name appears for the first time upon the Patent Office records on the 1st of June, 1869. It is a patent for a vote recorder. This was Thomas A. Edison's maiden patent, and is a device for recording the ayes and noes of a voting assembly. Two circuit closers are located at each voter's desk, and connect from the battery with two indicators, one for the ayes and the other for the noes. In the same circuit is a metal cylinder covered with chemically prepared paper, and adapted, when a circuit is closed at a voter's desk, to print either aye or no as desired. As the vote progresses, the cylinder is rotated and each voter's vote is silently recorded, the indicators at the same time checking the total vote. Since this patent was granted, Mr. Edison has taken over 150 patents, and I think I do not overestimate his abilities when I say that no other inventor has done so much to advance the entire art as has he.

Upon looking over his list of patents, I find him accredited with no less than forty-five patents upon printing telegraphs alone, many of which are in daily use in our stock exchanges.

The gravity battery of Jean Armand Callaud deserves a passing mention, and was patented October 17, 1871. It, like the Leclanche battery, is of such general public notoriety as to need no description here, and is perhaps in more general public use than all other kinds of batteries combined. It marks an important era in the art, in being one of the cheapest and most efficient of battery generators.

A passing mention must be noted here of the Gramme dynamo machine, patented Oct. 17, 1871, which is the first ring armature generator patented in America. Its construction is too well known to need description at my hands. The patent has expired by limitation of a foreign patent, and the invention is now public property. The Wilde machine, so well known in the art as the first dynamo with field magnets excited from an extraneous circuit, was patented in the year 1866, Nov. 13, and is now public property also.

We come now to an interesting invention in the patent of J. B. Stearns, 126,847, May 14, 1872, for overcoming statical disturbances on long duplex lines by the use of condensers. Prior to this invention it was not possible to transmit accurately two or more messages on existing duplexes over distances exceeding from thirty to fifty miles. Mr. Stearns conceived the idea of giving to the artificial line of a duplex telegraph an artificial electrostatic capacity which should equal that of the main or direct line. This he did by inserting adjustable condensers in a branch of the artificial line and adjusting them until no false signals occurred. This was the first great step in successful long distance telegraphy.

The patent has since been reissued by the Western Union Telegraph Company, Mr. Stearns' assignees, and suit has recently been brought under the reissue against the Baltimore and Ohio Telegraph Company, in New York. The patents are very valuable if they shall be sustained.

An invention which is of special interest from an historical standpoint is found in the patent to E. W. Siemens of April 14, 1874, which discloses the first unipolar magneto machine covered by patent in this country. It is so constructed that one pole of the field magnet lies within or is surrounded by the other pole, the armature being arranged to revolve or vibrate in the intervening field.

We now come to a dynamo which has peculiar interest at this time, because it is the parent machine patented in America, which depends upon the now well-known reactionary principle found in many of the better forms of dynamos in use to day. It was patented to Moses G. Farmer, April 13, 1875, and is not dissimilar, in its general construction, to the series-wound reactionary dynamos now found in public use. Although Mr. Farmer obtained a broad claim for the reactionary principle, it has since been discovered that Hjorth, Pacinotti, Siemens, and others had patented and described this applied principle in Europe as early as and even earlier than 1870, so that this patent merely stands upon the record as being the first to claim an applied principle which has since received such general and widespread application.

It is a remarkable fact that, by a strange chain of coincidences, many of the leading and essential features embodied in successful incandescent and are lighting, and also in dynamo machines to-day, are public property. It is only upon comparatively limited patents that existing light corporations are based, and this rightly by virtue of abandonment or public use on the part of the original inventors of these broad features.

The advent of the year 1876, the one hundredth anniversary of our national independence, seems to stand out in bold relief as a year of progress in the electrical art.

Prior to the first of January of this year, the Patent Office records note, all told, 1,923 patents.

On the 7th of March, 1876, a patent was issued to Alexander Graham Bell for a speaking telephone, which gave a new impetus to invention, and at once gave to the world an increased idea of the importance to be attached to that wonderful, intangible element—electricity.

From that date to the present, I cannot undertake to consider as I have in the foregoing remarks what individual inventions have been realized, and cannot even hope to give you a faint idea of what is disclosed in the 8,000 patents granted in less than ten years—more than four times the number previously granted in a period of nearly half a century.

In 1877 came Brush with his well-known dynamo and his improvements upon arc lamps, followed by Weston, Hefner-Alteneck, Thomson and Houston, and a host of others, until the list of inventors becomes almost legion.

You are all, I doubt not, quite as familiar with the existing state of the art disclosed by well-known apparatus in general public use as am I, since the apparatus in such general use is but a copy of that disclosed by the Patent Office. Telephony has grown from the parent patent of Bell to include more than 500 patents, arc lights as many more, and incandescent lights and fixtures a like number.

Whole new classes of invention have grown up in the period of less than ten years, until as they multiply we are forced to ask, When and where will this march of genius cease?

Capital has kept pace with this wondrous exposition of ingenuity, and finds itself ever ready to exploit and put in public use the inventions spread upon our records, until it has become almost an axiom that to patent an electric device seems to assure the inventor at least some revenue for his pains.

Amid all this clamor for investment in this mysterious field, the patent sharp has not been idle, and I regret to say that many capitalists have met with sad reverses because of investments in worthless patents or, perhaps I should say, worthless inventions based upon patents.

It is a matter of deep regret that this is true, for a few such unlucky investments do vastly more damage than one can estimate, by frightening away available capital from commendable inventions. However this may be, I cannot express much sympathy for any man who will invest his capital, without first ascertaining the probabilities of successful return.

One such a success as Prof. Bell's patent stands out as a Mecca of hope toward which all avaricious eyes are turned, and with a greed for gain which causes unfortunate investors to be swept into a veritable maelstrom of distress. Such princely incomes as it has been Prof. Bell's and Mr. Brush's good fortune to attain do not often fall to the lot of man, but rather tend to lure one on in the hope of some time reaching the goal of success.

I have sought in the preceding remarks to give you the written history, as briefly as possible, of the electrical art as we find it outlined upon Patent Office records, taking here and there as landmarks some leading or interesting patent, and tracing thus, step by step, its progress to the Centennial year, believing you to possess, as do most of our newspaper reading communities, a general information of the general history of the art from 1876 forward.

So much interest is now displayed in electrical matters, and so many are the facilities for attaining knowledge in that direction, that little need be said of the present history of the art, either in or out of the American Patent Office.

Every one who reads is familiar with the modern quadruplex, by which four messages are sent simultaneously over a single wire—the invention of Messrs. Nicholson and Edison.

The multiple synchronous telegraph of Delany was exhibited at your famous electrical exposition in 1884, as were, indeed, thousands of other interesting and important inventions which go to make up the more modern history of the art. These you saw, and learned, by actual practical application, of all the more important apparatus patented during the last decade.

I cannot close my remarks without saying something of the unwritten history of this wonderful art in the Patent Office, a history known only to the employes of the office, and oftentimes intensely interesting.

To you, and to every one, the published records of the Patent Office are open, and he who runs may read.

No one but an examiner of the Patent Office, and particularly an examiner in the electrical division, can form any conception of the wonderful workings of the human mind. It is to him that the most wonderful (?) inventions are unburdened, and he is forced to wrestle with electrical problems which would almost cause Faraday and Ampère to turn in their graves!

It is true that in the past, patents have been allowed to issue at which you have doubtless wondered, so inconsistent do they seem with existing laws, but the public can form no conception of the ignorance of alleged inventors in this art. So mysterious is the art to every one, that in the depths of that mystery reside visions of untold fortunes in alleged inventions, which never had a conception other than in the murky brain of their mysterious authors.

Our chief difficulty lies in electro-medical appliances, and the alleged inventions in this direction are legion.

I remember a few years ago, an applicant filed an application for curing nervous affections. It consisted of a copper wire earthed at both ends and carried over the bed of the patient in a north and south direction; that was all. Of course, it was refused for lack of utility, whereupon the applicant produced the affidavits of at least a dozen neighbors to prove that his wife was benefited and restored to health by the use of this simple and alleged effective device. This availed him naught, a patent was refused, and he appealed his case to a higher tribunal, where he again lost.

Another instance I recall is the small neck battery adapted to be worn about the neck of the patient, being about two inches in diameter, and having no excitant. It was refused as being inoperative. The applicant, not to be daunted, was cunning enough to place upon the exterior surface a design, and to take a design patent therefor, thus succeeding in accomplishing his end by getting the seal of the Patent Office. I have since seen a printed book of over 2,000 pages of testimonials from persons benefited by this alleged great electrical curative.

In another instance, an applicant devised an apparatus for generating steam in locomotive boilers, without the use of wood or coal. He first generated steam in the usual manner by the use of coal, and then caused this steam to actuate a local engine, and from it a dynamo, which generated electricity. This electricity actuated an electrical heater under the boiler, so that after once having started his locomotive, of course no more fuel was necessary—a clear case of perpetual motion. He was required to furnish a working model, which has not yet been received.

Perhaps the most amusing application which ever came under my observation is that for an improved "Method of Obtaining Rain by Art." I will take the liberty of quoting from the papers, in order that you may form some idea of the peculiar idiosyncrasies of this inventor.

He says:

"The object of my invention is to obtain rain by art as required and where required on the earth, snow falling in colder regions, thus rendering the deserts fruitful, and in time, D. v., opening up the Polar regions for settlement, and by withdrawing the rain from the atmosphere, relieving the tension from the ice in the Polar basins, thereby tending to preserve this planet, with all its inhabitants, from the destruction which is imminent, 2d of Peter, Chapter III., and Daniel IX., 25, being in danger of fulfillment.

"I use a captive balloon, the cable being attended by a cable or wire to the earth. This cable or wire may be covered with lamp-black, if required, to cause it to absorb solar heat and partially melt ice spicula attaching themselves to it, thereby preventing its breakage.

"The electricity is conducted from the higher strata of the atmosphere in such a way as to produce intense heat and melt floating ice spicula in the air, and precipitate it as rain.

"In this way, the temperature of the higher atmosphere will be lowered, floating ice spicula will be disseminated, and gradually the increase continued. Precipitation of ice at the poles of the earth will not only be discontinued, but a counter action will be set up, bringing the ice from the poles to the equator, and dissipating it as rain in the desert and other arid regions."

His specification is at once a curious medley of scriptural prophesies and alleged scientific facts, the latter to be found only in the curious mind of the inventor; it is not more curious, however, than is an assignment filed by the inventor, which I quote in full as follows:

"Should I die before the patent for obtaining rain by art is applied by me, I desire the government to work the patent, devoting half the profits to endow the widows' and orphans' homes, into which no clergymen will be allowed; the only prayers to be offered within the walls being those in Holy Scriptures; the only praise to God being the Psalms of David and other songs of praise in the Holy Bible; the orphans to be instructed into Holy Scripture from infancy, such portions as are suited to their years. When beyond the age of twenty-one years (seventeen females), each to either translate from the Hebrew or Greek the whole Holy Bible, or write a copy of it with their own hand in their own language. The males not to marry until thirty-three years, the females until the age of twenty-five years. Should they become widows or widowers, and wish to marry again, they shall only marry widows or widowers of proportionate age; each orphan to be thoroughly instructed into that branch of science or art to which their mind shows a natural bent, scientific agriculture being prominently held forth to those who wish to adopt it; the girls to be fitted for the positions of governesses, teachers, etc., the widows to be taught branches of needle work, knitting, etc., so that the result of their labors may be devoted to the benefit of the inmates (and if possible outside poor) in clothing, etc.; prayer and praise to be offered three times daily to the Almighty God. The use of flesh as food, if found practicable, under the observation of unprejudiced, scientifically educated physicians, to be prohibited. Abundance of all edible vegetables, grain, etc., of which the leguminous will be in large proportion, together with milk, butter, cheese, honey, and fruits, to be used. From the age of twenty-four to twenty-nine years, the males to contribute one-third part of the net profits of their labor toward the further endowment of their home. The right of amending this testimony for the benefit of all is reserved by me.

"I desire all the nations using the methods of my discovery to similarly endow such widows' and orphans' homes.

"The other half of the profits to be given to my poor relatives, to be invested by them in profitable securities for their own use and benefit."

These are fair samples of many alleged inventions which yearly come before the electrical examiner of the Patent Office, and as surely find themselves buried in the record of abandoned applications.

You will, of course, appreciate the fact that but little can be said of the secret history of invention, for the reason that the policy long pursued of preserving pending applications in secrecy must necessarily impress one with its entire fairness to all.

I have made no breach of my official relations in enumerating the cases above referred to, for the reason that it is entirely apparent that these cases must rest without the possibility of ever being blest with the official seal of the Patent Office.

This unwritten history embraces also many inventions of great practical utility which lie buried in secrecy for reasons known only to their authors; they tell oftentimes the sad story of want, privation, and suffering, sleep for years only to be resurrected after some more fortunate independent inventor has succeeded in reaching the desired goal.

There is very much of interest and importance in this secret history, and were the records of abandoned cases made public, as in my opinion they should be, the art would receive much that is valuable which will now remain a sealed book forever.

In conclusion, I beg to call attention to the very important position which the Patent Office records hold

in the written history of the art and to the fact that our patent system is the best which the civilized world ever knew.

We stand to-day at the head of the civilized world as being the one nation noted for its great inventions. Our ingenuity as a nation of inventors is far-famed. It is due not alone to a peculiarly ingenious people, but rather to the fact that the humblest citizen realizes that for a mere pittance he can patent and secure from his government a monopoly of his invention for a limited time.

The system has stimulated inventive genius wherever it offers itself, and to-day we find ourselves a nation of educated people whose homes are surrounded with all the comforts which civilization can give us.

Education has joined issue with ingenuity, and the two march hand in hand, each stimulating the other and each vying with the other in seeking to see where and how the most can be done to elevate the human race to the plane of an all-wise Creator.

Who can tell where it will end? Who can tell what will be the future of such a nation?

PASTEUR'S TREATMENT OF RABIES.

IT is just ten years ago that Bouley, who was commissioned to draw up an article on rabies for the Encyclopedic Dictionary, wrote at the head of his work the following lines: "The question of rabies, which is so many centuries old, is nevertheless ever new, for this disease always remains pregnant with all its menaces, and just as fecund in disaster as in the past." Eight days before his death, surmounting by force of energy the suffering and fatigue caused by the affection that was to carry him off, Bouley presided over a session of the Academy, and had the supreme satisfaction of hearing Mr. Pasteur announce that it was thereafter possible to battle with rabies with a certainty of success, thanks to the prophylactic vaccinations of which he then made known the details.

Of all the diseases that afflict humanity, rabies alone has hitherto remained refractory to the most varied and most heroic treatment. Phthisis and cancer, which enter so largely into the tables of mortality of all countries, can, in certain cases, although unfortunately too rarely, be eradicated, cured, even by therapeutic means. Every physician will cite to you examples of consumptives who have been perfectly cured; and every surgeon will give you convincing instances of extirpation, followed by a radical cure, of a carcinomatous tumor, where it was accessible to his instruments. But for rabies, no cure has ever been announced. So it is easy to understand the sensation that was produced by the announcement of the discovery of a means of preventing the disease; and we have a right to say with Bouley that the date of this session of the Academy will ever remain memorable in the history of medicine, and forever glorious for French science, since it is the date of one of the greatest progresses that has ever been accomplished in the domain of medicine.

It was in 1880 that Mr. Pasteur took up his first researches on rabies. A child afflicted with this malady had just died in Dr. Lannelongue's ward at the Trousseau Hospital. The saliva was collected, and a microbian element isolated; but this latter, which till then had been unknown, and which might, *a priori*, have been considered the generating element of the disease, did not produce rabies. It was then that Mr. Pasteur, being convinced that the secretion of the salivary glands was not the sole seat of the virus, bethought himself to look for it in the nervous centers. He found, and showed it by a series of decisive inoculations, that the brain, the rachidian bulb, and the entire spinal marrow were the centers of localization of the virus. This discovery soon led him to devise a method of inoculating which considerably abridged the long and varied period of incubation. If the nervous centers were the chief foci of the virulence, why not endeavor to inoculate the disease at once at the spot where it localizes itself, where the virus develops and presents its maximum power? Facts confirmed such a hypothesis, and direct inoculation under the dura mater, after trepanning, put the experimenter in possession of a method capable of developing rabies in a very short space of time.

This operation is quite simply performed: The cranium is laid bare by a small crucial incision, and the trepan is applied to the bone, and through a few revolutions detaches a disk of bone. It is this phase of the operation that is shown in Fig. 1. Inoculation is then effected by pushing the needle of a syringe charged with the rabid product under the dura mater. The wound is closed by two stitches.

This first solution was of considerable importance, for it would have taken weeks or months to learn the result of subcutaneous inoculations, and it would have been almost impossible to follow with regularity the concatenation of the experiments by series. It was possible, then, to produce rabies at will, and in a very short time. The only thing to be done now was to take advantage of what had previously been learned as to the attenuation of virus, and endeavor, through successive cultures, to progressively lessen the harmfulness of the rabid poison. At this moment Mr. Pasteur found himself in the presence of a difficulty that would have caused more than one experimenter to recede. Rabid virus cannot be cultivated like the viruses of charbon, chicken cholera, and so many other affections. It exhibits itself under a different form from that of all other viruses hitherto known; and neither bacilli nor micrococci are found. It consists simply of fine molecular granulations, which may be colored with the salts of aniline, but the culture of which has not as yet been attended with success. Mr. Pasteur has tried the most varied liquids, such as serum, cephalo-rachidian liquid, bouillon, etc., but with constant failure. Is there, then, no rabid microbe? No; not if we understand thereby a bacillus, a well defined element more or less analogous to that of rubeola, charbon, and others; for it exists only under the form of these fine granulations. Give Mr. Pasteur or one of his assistants two brains, one healthy and the other rabid, and either will tell you, on simple inspection of the bulb, which belongs to the mad animal.

For want of cultures capable of showing whether the virus keeps on attenuating, Mr. Pasteur proceeded to inoculate with weaker and weaker doses of the rabid virus. Into one dog he injected a cubic centimeter of the virulent liquid; into another, one one-hundredth of a cubic centimeter; and into a third, a still smaller dose. All three contracted rabies, and it was precisely the one that got the smallest dose that was the most violently attacked. The inoculation of small quantities, as may be seen, is far from giving immunity.

But, although the virus cannot be attenuated by culture, it may vary according to the species of animal, and exhibit different degrees of virulence through the inoculation of one species by another. This was foreseen, and was the starting-point of the method that allows dogs to be rendered refractory to rabies. If we transfer rabies from the dog to the monkey, then from the monkey to the monkey, the virulence of the virus weakens at every transfer. If this weakened virus be afterward applied to the dog, Guinea pig, or rabbit, it remains attenuated, and direct inoculation of the brain produces no symptoms, and renders the animal proof against the most virulent inoculations. This process, upon whose details I cannot expatiate, does not constitute a practical method capable of certain and easy application to the human species.

As Mr. Pasteur says, a prompter means was necessary, and one capable of giving perfect security against dogs. This difficulty has been overcome through multiple experiments.

By performing inoculations by series, which might be called descending ones, that is to say, by making successive transfers from one animal to another of the same species, we succeed in obtaining a degree of virulence of proper fixedness for each species of animal, and one that we are so sure of that we can tell to within a few hours when the disease will break out. If, for example, we inoculate a rabbit with the rabies of a dog, the symptoms will exhibit themselves after a fortnight of incubation. If we pass from the first rabbit to a second, then to a third, and so on, the virulence seems to increase in the sense that the duration of incubation is more and more diminished. After twenty-five transfers, it becomes eight days only; and after twenty-five more, only seven days. This is very likely the minimum period of incubation, since, on continuing the inoculation up to the ninetieth series, the figure of seven days is not modified. Under such circumstances, we are sure, then, of having a pure rabid virus of constant stability, and in such quantities as may be necessary for inoculating a certain number of animals.

This does not give us an attenuated virus, but, on the contrary, one of powerful activity. But if we take the spinal marrow of these animals, which contains the virus throughout its entire extent, and expose it in fragments to the action of dry air, we shall see the virulence progressively lessen, according to the size of the fragment and the condition of the external temperature, and finally entirely disappear. It will suffice, then, to take one of these fragments at a given moment, in order to have an attenuated virus like that which would have been obtained by a series of cultures were the latter possible.

Let us inoculate with the weakest virus, then successively, by gradation, with a stronger and stronger one, and we shall render the organism of the animal submitted to the operation refractory to rabies. This is demonstrated by experiment, and the following is the method by which Mr. Pasteur renders dogs proof against the disease in a relatively short time.

In a series of flasks, in which the air is kept dry by fragments of potassa lying on the bottom, we daily suspend a piece of rabid spinal marrow fresh from a rabbit killed by rabies developed after seven days of incubation. We daily inject under the dog's skin a Pravaz syringeful of sterilized bouillon in which has been steeped a small fragment of dried marrow—beginning with a piece of a series—number distant enough from the day in which the operating is being done to be very sure that the said marrow is not all virulent.

On the following days we operate in the same way with fresher spinal marrow, separated by an interval of two days, until we reach a final very virulent marrow that has been in the flask but one or two days. The dog is thus rendered proof against rabies, and can be inoculated under the skin or even at the surface of the brain with rabid virus without being given the disease. The problem of a prophylactic against rabies has been found.

Fifty dogs treated by this means have now remained for many months absolutely proof against the most virulent inoculation. The preventive found for the dog guarantees success in cases of human rabies, provided the victims can be treated in time. In man, the period of incubation of rabies varies from three to four weeks to some months. If, then, at the beginning of the disease, we perform a series of inoculations of increasing intensity, we shall succeed, before the occurrence of a symptom, in developing in the organism an impregnation that will confer the same immunity to the patient as to the dog.

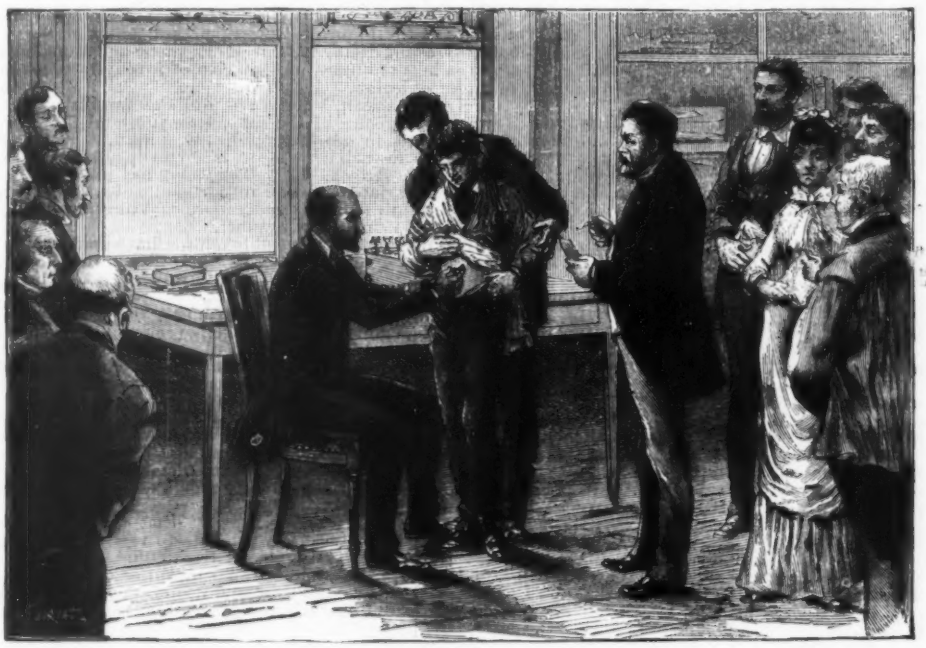


FIG. 2.—INOCULATION OF A PATIENT AT MR. PASTEUR'S LABORATORY.

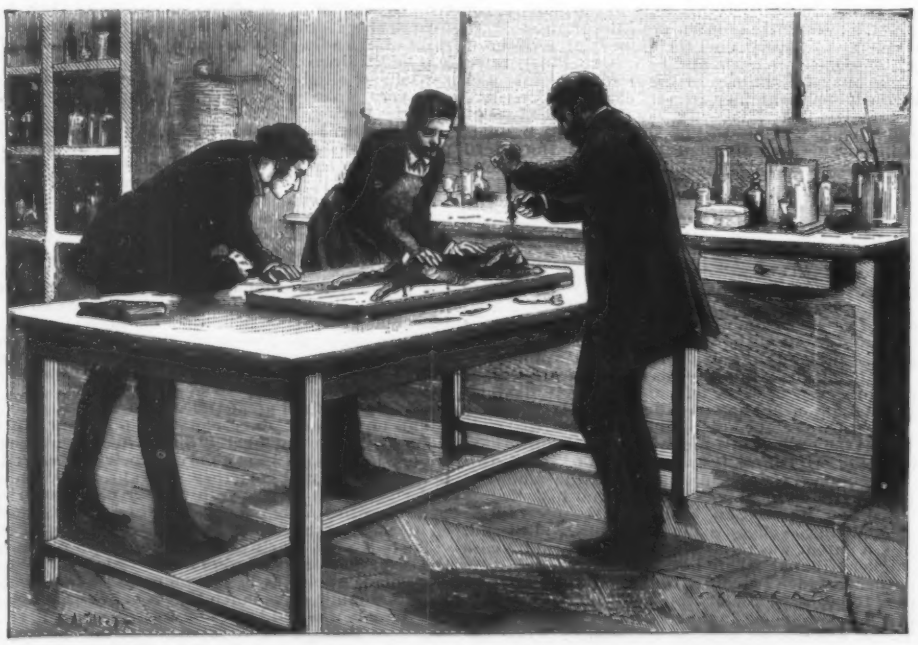


FIG. 1.—THE TREPANNING OF A RABBIT AT MR. PASTEUR'S LABORATORY.

It is clear that when the period has arrived at which the patient's symptoms are exhibiting themselves, and the evolution of which at this moment scarcely exceeds three days, no benefit can be derived from the treatment. It would be just as if one were to vaccinate a patient in whom the small pox was breaking out—the preservative would be of no avail.

Mr. Pasteur was soon to find an occasion to confirm the accuracy of his experiments by an application to man. All the newspapers have given the history of young Meister and of the shepherd Jupille, and I shall therefore confine myself to summing up the chief points in these two cases.

In the month of July, 1885, Meister, a boy nine years old, was badly bitten by a mad dog. The wounds were deep, and fourteen in number, and were not cauterized till twelve hours after the biting. The material used was phenic acid, the potency of which in such cases is illusory. He reached Mr. Pasteur's laboratory two days later. After the opinion given by Professors Vulpian and Graucher, of the faculty of medicine, that the boy was in certain danger of having hydrophobia, seeing the number and seriousness of the bites, Mr. Pasteur did not hesitate to try inoculation with his attenuated viruses. The first inoculation was performed with sterilized bouillon containing a fragment of a rabbit's marrow that had been dried for fifteen days.

The next day a new inoculation was made with a marrow of fourteen days, then so on, day by day, with a marrow of twelve, eleven, and so forth, down to that of one day. Simultaneously with this, rabbits were inoculated, as controls, with the same product. The first nine inoculations were not virulent, that is to say, with the marrows of fifteen to seven days, but all the rest were, and developed rabies in the space of time indicated for animals. At the last visits, the child, then, was inoculated with the most virulent virus—that of the dog strengthened by a host of passages from rabbits to rabbits—a virus that gives these animals the rabies after seven days of incubation, and dogs after from eight to ten days. The success was decisive, and the child has kept remarkably well since the eight months ago that the treatment was applied to him. He has escaped the hydrophobia that he would have had on account of his wounds, and, granting with skeptics that the dog was not mad, he resisted the inoculations of the rabid virus of a maximum strength, by virtue of the progressive attenuations.

Cases of biting by mad dogs are quite numerous, and so much the more so in that (as has been established by statistics) the administration of Paris is less rigorously applying police measures against vagrant dogs. Cauterization, and a heroic one with a red hot iron, very shortly after the bite certainly prevents the development of rabies; but if, for one reason or another, the cauterizing is delayed or badly done, the disease may appear after many months, the victim being left a prey in the mean time to the terror of one condemned to death; or it may attack him after he has already forgotten a wound that is sometimes insignificant.

The history of young Meister quickly became known. A few days later, the shepherd Jupille, bitten in both hands, came to submit himself to treatment. Then, as soon as the communication to the Academy was disseminated by the journals, the laboratory in Ulm Street became a genuine hospital. The victims of mad dogs flocked from all quarters to implore the benefit of Mr. Pasteur's treatment. There were the "gens de Brie," as they were familiarly called by the master, and Germans and other foreigners of both sexes and all ages—a little world, which came every morning and filled the waiting-room adjoining the laboratory.

The American journals were not the last to publish the news of our compatriot's success, and so, behold one fine day four children landing at Havre, under the charge of Dr. Frank Billings, in order to undergo the preventive inoculations. These four children, aged 5, 10, and 14 years, had been bitten by the same dog, two of them seriously. Through the generosity of the citizens of Newark, who took up a public subscription, and of the Transatlantic Company, it became possible to send the patients to France. They reached Paris December 21 (nineteen days after being bitten), were submitted to treatment (ten inoculations), and started for America January 2, where they fell into the hands of a showman, who exhibited them in public.

Prof. Graucher is good enough to perform the inoculations under the eyes of the master, who oversees all the preparations, examines the patients, and has a kind word for each in order to reassure him and keep up his courage. The liquids containing the fragments of attenuated virulent marrow are brought all freshly prepared in the morning. An assistant fills the hypodermic syringe with the proper liquid, varying the virulence every day, as for young Meister. Each patient passes before Prof. Graucher, with his clothing raised above his waist, and the injection is inserted in the abdominal region, one day to the right and next day to the left (Fig. 2), without the patient experiencing any other sensation than that of a slight prick. The dose varies slightly, according as the patient is an adult or a child; the entire contents of a syringe for the former, say about a cubic centimeter of liquid, and half a syringe for children under fourteen years of age. The wounds are dressed by Prof. Graucher's house surgeon, and the patients go home and return the next day for another injection. From eight to ten days' treatment, say from eight to ten inoculations, suffice for the graduated series, from the most attenuated up to the most virulent. More than three hundred patients have undergone this prophylactic treatment. The details of his numerous observations were made known to the Academy a few days ago by Mr. Pasteur.—*Dr. A. Cartaz, in La Nature.*

PASTEUR AND HYDROPHOBIA.

AT the session of the Academy of Sciences on March 1, M. Pasteur communicated a report of his progress in the treatment of hydrophobia down to that date. On February 25, four months after he announced his discovery, he had treated his 350th patient. He had been astounded to learn the number of persons who were bitten by supposed mad dogs. Taking the first 100 persons treated between November 1 and December 15, he declares that all are now out of danger with the one exception of the girl who died. She had been bitten thirty-seven days when treatment was commenced, and M. Pasteur claims her case as a conclusive proof of the effect of inoculation. Experiments on rabbits showed that although she was not saved, the effect of the virus was much diminished. M. Pasteur's report was received with great enthusiasm, and the Academy immediately decided to form a commission charged with the duty of founding an institution in Paris for the treatment of hydrophobia. It was suggested that an international subscription to defray the expenses of this foundation should be proposed. M. De Freycinet, President of the Ministerial Council, who was present, was named on the commission.

EXPERIMENTS ON EVAPORATION.

AT a recent meeting in New York of the American Society of Civil Engineers, an extremely able and interesting paper was read by Mr. Fitzgerald "On Evaporation," of which the following is an abstract from *Engineering:*

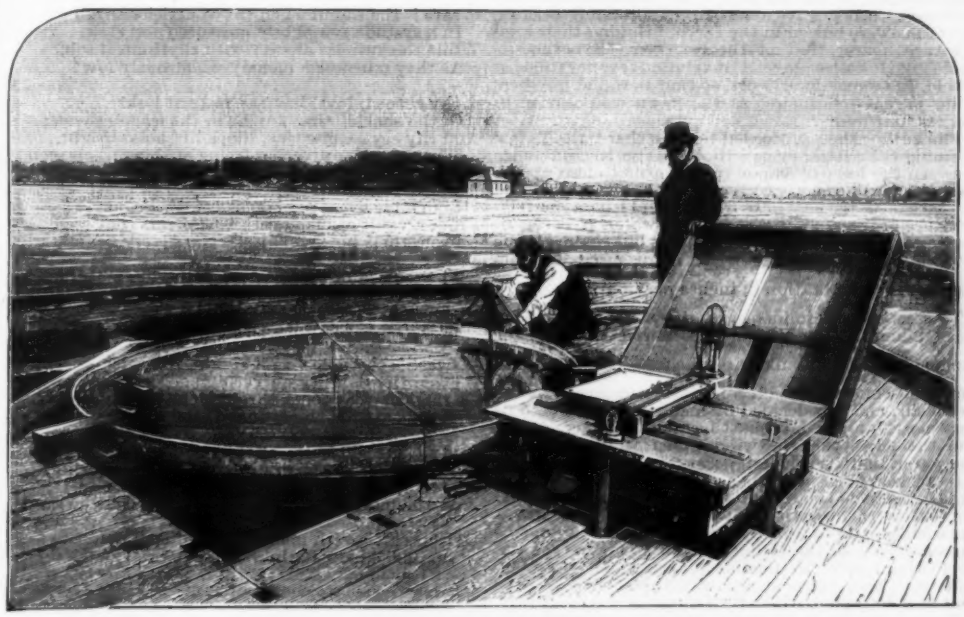


FIG. 1.

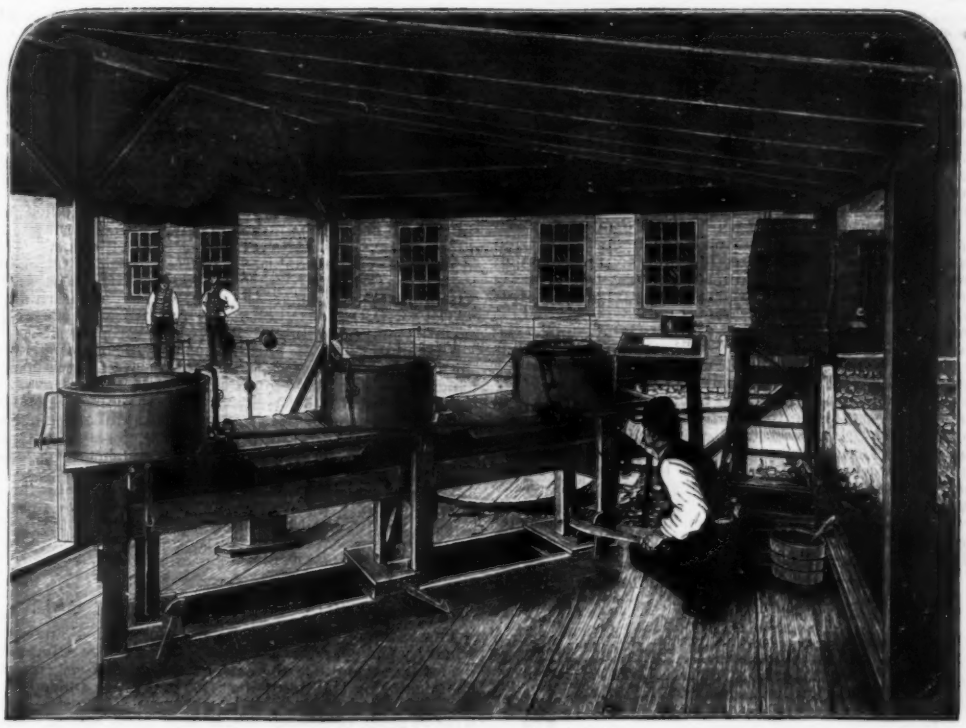


FIG. 2.

APPARATUS FOR TESTING SURFACE EVAPORATION.

The experiments dealt with were commenced ten years ago at Chestnut Hill Reservoir, Boston, Mass., with a box sunk in a metal tank; but in endeavoring to arrange them a year ago for publication, the author found so many complications involved that he resolved to make a new set of experiments. He had a tank constructed 10 ft. in diameter on a raft, so that it could be floated from point to point. The staves forming the sides of this tank were separated from each other to allow a free flow for the water, and were lined inside with copper. The arrangement is shown by the upper view published. It was believed that by this method the temperature inside the tank would be the same as that of the reservoir; this, however, proved not to be the case. The problem to be solved was the rate of evaporation of water from a large surface; and, as has been stated, the data ran back over a series of years, the author's present purpose being to verify the data from the present experiments and connect them with what had preceded them. Self-recording instruments were used, and every effort made to eliminate friction, or at all events to get it to the lowest point; practically, it was reduced to an insignificant quantity. The evaporation in a certain week considered as a maximum was 0·64 in. in a day, and this the author had never known exceeded in any other recorded observations. The instruments were self-recording thermometers and self-registering thermographs. The wind, humidity, evaporation, etc., were all carefully taken and systematically recorded.

The evaporation in winter months has heretofore been assumed as a negligible quantity, but the author was able to demonstrate the great error of this assumption. He took a series of experiments to show evaporation from ice and from snow surfaces, and from a mixture of snow and ice. The ice surface was tested by means of a pan 14 in. by 18 in., these dimensions being chosen because $\frac{1}{10}$ in. on that surface is equal to an ounce. The ice cut thin and planed down was fitted into the pan, and observations were made showing the law of evaporation from ice surface or snow surface to be the same as that from water.

In conducting these experiments the author remarked a phenomenon. The reservoir is seldom frozen over before December, and in 1885 it remained open even then, freezing in January, 1886. Passing the reservoir after a week of warm weather, the author noticed clouds of vapor arising from the water, the thermometer being 12 deg. Fahr., and the temperature of the water being 38 deg. The atmosphere on falling suddenly in temperature contained very little moisture, and the water being at a much more elevated temperature gave a high evaporation. On observing the humidity, temperature, and wind, the author found the water evaporating at the rate of 0·23 in. in twenty-four hours. Although this was to be considered an extreme case, it shows it will not answer to neglect evaporation in winter. The variations in the recorded diagrams seemed at first puzzling, but theoretical investigations verified them.

Under ordinary ranges of temperature, the surface of water is about 60 deg., and it reaches its maximum about 3 P. M. If the day is hot, it does not attain the maximum till 7 P. M., and the mean temperature is

about the same at night as during the day, since it takes all night to lose what it has gained during the day. The author further found that relative humidity had nothing to do with it, thus verifying Mr. Dalton's statement to this effect. The evaporation from a large area was also found to be very much greater on a cool day than on a hot one. The maximum evaporation noted, 0·64 in., occurred on a cool day succeeding a hot week. The author thought previous experiments on evaporation not reliable, because they were made on small surfaces and exposed above ground, where the wind struck the sides and bottom of the tank. Mr. Greeve's experiments, made in England, extended over twenty years, and gave 25 721 in. rainfall and 20·613 in. evaporation, about 80 per cent., while the present experiments gave rainfall 48 in. and evaporation 39 in., or about the same ratio. A comparison was then made between the experiments made by Mr. Croes and those by the author. Mr. Croes obtained 48 in. for the annual evaporation as against 39 in. by the author, but the former experiments were based on the use of tin tanks instead of wooden ones. Mr. Croes' experiments at Boyd's Corners gave a less result, probably because the tanks were buried in the earth, bringing their temperature nearer that of the reservoir. Experiments made by M. Salles gave a maximum evaporation of 0·56 in. in twenty-four hours, so that in round numbers ½ in. may be considered as the mean evaporation in twenty-four hours.

The author then proceeded to show that Dalton's law claiming the entire evaporation to be the difference between the force of vapor in the atmosphere and in the water, while nearly correct, was not exact. He cited the case of water heated to 86 deg., and where the temperature of the air was less. In the water, particles of vapor are evolved with great facility, but in the air the force of vapor is very small. A more exact formula was $\frac{V-v}{60}$ = evaporation in inches per hour.

To ascertain the influence of the wind, experiments were taken out of doors with aerometers at the same height as the tanks, and the formula $\frac{V+1}{2}$ gave the results of evaporation from water surfaces exposed to the air, and was decided by many experiments to be very close, but the data must be taken very accurately, and the velocity of the wind taken at the surface of the water, and also the temperature at the same point.

In answer to a question as to whether the depth of the tank affected the results, the author stated it did not, except so far as it influenced the temperature at the surface, and that he had found greater evaporation from a deep pool than from a shallow one; the shallow pool rising rapidly in temperature also cooled rapidly, and the mean temperature was therefore less than that of a deep pool, which rises slowly and cools slowly.

To the inquiry as to whether the temperature was taken in the reservoir as well as in the tanks, the author replied it was; and the two temperatures corresponded pretty nearly, although in March he had found the water in the tank 10 deg. higher than in the reservoir in which it was floating. As the season advanced, however, this discrepancy disappeared, and at the close of the season the temperature in the tank was a little lower than in the reservoir. The mean was about the same, although, as stated, there was at times a difference due to circulation and radiation. As the raft was constantly moving about, it always presented the same form to the wind, and protected the tank against the waves, thus keeping the water in it free from disturbance and at the same level as that of the reservoir.

In order to ascertain if the pressure of the atmosphere affected the evaporation, experiments were tried on water under an air pump, in order to obtain much greater changes in condition than those afforded by the ordinary barometric observations; and after a careful series of experiments, the author concluded it amounted to nothing in the ordinary conditions. To elucidate further the law of evaporation, the author explained it was simple, although many writers seemed desirous of mystifying the subject, and illustrated it by taking a barometer tube, and putting a little water in the top. At a certain temperature, the mercury is forced down proportionately to the force of vapor from the water, V, and the vapor that is in the air, v, presses upon the water with a force due to its temperature: the difference between them being the rate of evaporation, or $V-v$.

The following table shows the mean observed evaporation at Chestnut Hill Reservoir, near Boston, Mass.:

Mean Observed Evaporation at Chestnut Hill Reservoir.

January	0·90
February	1·20
March	1·80
April	3·10
May	4·61
June	5·86
July	6·28
August	5·49
September	4·09
October	2·95
November	1·63
December	1·20

The lower illustration shows the arrangements for making tests of evaporation under varying circumstances and at different temperatures, great attention being paid to shielding the testing tanks from the wind, and also noting the effect when the wind acted on them. The shed was so arranged that the wind could be completely shut off by curtains.

A NEW INDUCTION IN SPECTROSCOPY.

THERE are reasons to suspect that the spectroscope has not told us the entire truth of gaseous nebulæ, and that solid bodies, varying greatly as to number and size, are frequently important constituents of them. Probably, nebulæ vary indefinitely in the relative proportions of the solid and gaseous matter in their composition, from those which are nearly purely gaseous to those which contain scarcely anything but solid bodies. If these were exceedingly numerous, so as to overpower the gaseous spectrum of the nebula by the continuous spectrum they gave, and yet none was sufficiently large to appear as a distinct star, we should have presented to us the very features we recognize in the Andromeda nebula, and Sir John Herschel's prevision, made more than half a century ago, would be realized, that "the great nebula in Andromeda may be, and not improbably is, optically nebulous owing to the *smallness* of its constituent stars." The cause of the appearance of these temporary stars still remains to be found. If we accept Denning's observations as proving that meteor streams moving with a velocity of 200 miles per second and upward are features of interstellar space, the passage of such a stream through a nebula might produce all the phenomena of a temporary star.—*Observatory, October*, 1885.

THE ANATOMIST'S ODE TO HIS MISTRESS.*

I LIST as thy heart and ascending aorta
Their volumes of valvular harmony pour;
And my soul from that muscular music has caught a
New life 'mid its dry anatomical lore.

O rare is the sound when thy ventricles throb
In a systolic symphony measured and slow,
While the auricles answer with rhythmical sob,
As they murmur a melody wondrously low!

O thy cornea, love, has the radiant light
Of the sparkle that laughs in the icicle's sheen;
And thy crystalline lens, like a diamond bright,
Through the quivering frame of thine iris is seen!

And thy retina, spreading its luster of pearl
Like a far away nebula, distantly gleams
From a vault of black cellular mirrors that hurl
From their hexagon angles the silvery beams.

Ah! the flash of those orbs is enslaving me still,
As they roll 'neath the palpebræ, dimly translucent,
Obeying in silence the magical will
Of the ocular-motor—pathetic—abducent.

O sweet is thy voice, as it sighingly swells
From thy daintily quivering chordæ vocales,
Or rings in clear tones through the echoing cells
Of the antrum, the ethmoid, and sinus frontales!

And stately the heave of thy maidenly breast
As the swell of the billow swift rolling to land;
And as soft the vesicular sigh in thy chest
As the moan of the ripple that ebbs o'er the sand.

But alas! 'tis with many forebodings I pen
Anatomical verses thy beauty to praise,
For I fear me my studies will never again
Bring the solace they had in my happier days.

Thou hast stolen the charm from my studio dim—
From dissection I turn with embittering wrath—
Thou hast stepped betwixt me and my skeletons grim—
Ah, lady! fair lady! why crossed ye my path!

THE EURHODINES, A NEW CLASS OF COLORING MATTERS.

By OTTO N. WITT, Ph.D.

BY acting with orthoamidoazo compounds on α naphthylamine hydrochloride, new dye stuffs may be obtained, which have received the name of *eurhodines*. The typical eurhodine, prepared from amidoazotoluene and α naphthylamine, crystallizes in orange needles. Its solution in ether is yellow, and shows a brilliant green fluorescence. Its salts are of a scarlet color. The formula of eurhodine is $C_{11}H_{11}N_3$. By the action of acids it is transformed into eurhodol, $C_{17}H_{13}N_3O$, while ethylic nitrate produces the ethylic ether of eurhodol, $C_{17}H_{11}N_3OC_2H_5$. Eurhodine is recognized as amidonaphthylenetoluquinoxaline.

A large number of eurhodines may be obtained synthetically by the action of orthodiketones on triamines which have two of the amido groups in the ortho position. The substance $C_{20}H_{12}N_4$, formed by the action of phenanthraquinone on 1:3:4 triamidobenzene, has been examined, and found to resemble closely the typical eurhodine. The joint oxidation of orthotoluylenediamine and α and β naphthol has been studied. α naphthol produces a blue dye belonging to the indophenol group, while β naphthol gives rise to the formation of a new naphthalenetoluquinoxaline. As only two of these are capable of existence, the new compound must be the $\beta\beta$ isomeride.

ESTIMATION OF ZINC IN ZINC ASH.

THE sample is first submitted to mechanical analysis, whereby the coarser and finer portions are separated by sifting, weighed, and afterward separately treated chemically by the following: 100 grms. are placed in a flask, covered with a little water, and digested first with 96 grms. of strong nitric acid (1·33 sp. gr.), and afterward with 192 grms. of hydrochloric acid (1·19 sp. gr.). After standing at rest for ten hours, the fluid is decanted, and the insoluble portion, having been triturated in a mortar, is again treated with nitric acid on a water bath till completely oxidized. The acid fluids are mixed, and the insoluble portion having been collected is washed with cold water, and all the filtrates and washings made up to a bulk of 4 liters. 8 c. c., equaling 5 grms. of the sample, of this liquid are saturated with sulphureted hydrogen to precipitate lead, copper, etc. As, however, this precipitate always contains distinct traces of zinc, it must be redissolved into nitric acid, evaporated with sulphuric acid to expel the nitric, and again precipitated by sulphureted hydrogen.

The mixed filtrates now containing all the iron and zinc are evaporated to a convenient bulk, and oxidized by means of bromine water. To separate the iron and zinc in this liquid, the author prefers to pour it into an excess of dilute ammonium hydrate, whereby the iron is precipitated as ferric hydrate, containing also a trace of zinc, while the bulk of the latter is left in solution. The precipitate is redissolved in hydrochloric acid, and once more treated with ammonium hydrate, when the separation becomes complete. The mixed ammoniacal liquids now containing all the zinc are acidified with acetic acid, and the zinc having been precipitated by sulphureted hydrogen is weighed as zinc sulphide, with the usual precautions.—*L. de K.; L. Marquardt, Zeits. f. Anal. Chem.*, 25.

* Written by a medical teacher of New York, when a student.

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